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TABLE OF CONTENTS

Vol. 24 March, 1941 No. 3

THE JOURNAL

Note on Moisture Expansion of Ceramic Whiteware in Storage and in Service 77–79
By R. F. Geller and A. S. Creamer
Thermal Expansion of Silicate Fluxes in Crystalline and Glassy States 80–84
By H. J. Orlowski and C. J. Koenig
Effect of Repeated Wetting and Drying on Physical Properties of a Clay Body 84–88
By W. R. Morgan
Physical Properties of Massive Topaz 89–92
By J. L. Stuckey and J. J. Amero
Factors Affecting Reflectance 92–96
By Clark Hutchison and F. W. Nelson
Effect of Residual Color on Consumer Acceptance of Porcelain Enamel Whites 97–100
By John W. Iliff
X-Ray Study of Potash-Silica Glass 100–102
By J. Biscoe, M. A. A. Druesne, and B. E. Warren
Elastic and Viscous Properties of Several Potash-Silica Glasses in the Annealing Range of Temperature 103–109
By N. W. Taylor and R. F. Doran

CERAMIC ABSTRACTS

20—3

Abrasives 61
Art and Archeology 62
Cements 63
Enamel 64
Glass 64
Structural Clay Products 69
Refractories 70
Terra Cotta 71
Whiteware 72
Equipment and Apparatus 73
Kilns, Furnaces, Fuels, and Combustion 74
Geology 74
Chemistry and Physics 76
General 77

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NOTE ON MOISTURE EXPANSION OF CERAMIC WHITEWARE IN STORAGE AND IN SERVICE*

By R. F. Geller and A. S. Creamer

Abstract

Eighteen samples of wall tile and 15 samples of tableware, which had been in service or in storage for periods of time ranging from 23 years to less than 1 year, were tested to determine how much moisture expansion had taken place. Selected samples were also autoclaved, and the resultant moisture expansions were compared.

I. Introduction

In his pioneer work on the moisture expansion of ceramic bodies, Schurecht[1] gave sufficient data to show that the expansion taking place during a comparatively brief autoclave treatment is definitely related to the expansion during long exposure to air. In Schurecht's reports, however, as well as in numerous later reports on moisture expansion, there are insufficient data to show the expansion that develops during varying lengths of time in storage or in service.

In an endeavor to supply the information that is lacking, samples of wall tile and of tableware were solicited from several manufacturers and determinations were made of the moisture expansion which had taken place since the ware had been made.

II. Materials and Methods

The 33 samples investigated are described in Table I. Those designated as having been in plant storage were supplied directly by the manufacturer, together with the body compositions. The "show-case" specimens were taken from the ceramic exhibit at the National Bureau of Standards. Those in domestic use were supplied by the investigators.

Moisture expansion was determined by the interferometer method described by Schurecht.[1] The specimens, in the form of the letter V, were sawed from the samples with a thin abrasive wheel and were ground to remove the glaze and to form a supporting point, or "foot," at the apex and at the end of each arm of the V. Proper care was exercised to avoid local heating of a specimen during the grinding process.

Absorption was determined by weighing pieces of the samples before and after autoclaving in water for 5 hours under a steam pressure of 150 lb. per sq. in.

III. Results

The results on moisture expansion during storage or service are given in Table I and plotted in Fig. 1.

Unfortunately, the only specimens which may be compared to determine if actual use will produce more expansion than storage are specimens L-32-IC and L-32-IP. Although this comparison shows no significant difference, it should not be concluded that every ceramic body will show the same relative moisture expansion whether in storage or in service.

IV. Supplementary Data

As the data in Table II show, specimens of 12 of the 33 samples were subjected to three arbitrarily chosen autoclave treatments of varying severity. The specimens were preheated before autoclaving to eliminate any moisture expansion which had occurred during storage or service. In addition, glazed pieces of nearly all of the bodies tested were autoclaved as received, and the effect on the glaze was noted.

The mildest of these treatments (150 lb. per sq. in. pressure for $^1/_2$ hr.) produced more expansion (except for specimens B-37 and C-34) than had taken place during storage or service even though in some cases from 15 to 23 years had elapsed since the samples were manufactured (e.g., specimens L-25-WP, G-24, and J-17-PE). It should not be assumed from the limited data in this report that an autoclave treatment of 150 lb. per sq. in. for $^1/_2$ hr. is necessarily sufficient to determine the suitability of glazed ware under severe service conditions, such as tile in tunnel walls or glazed brick and terra cotta exposed to the weather.

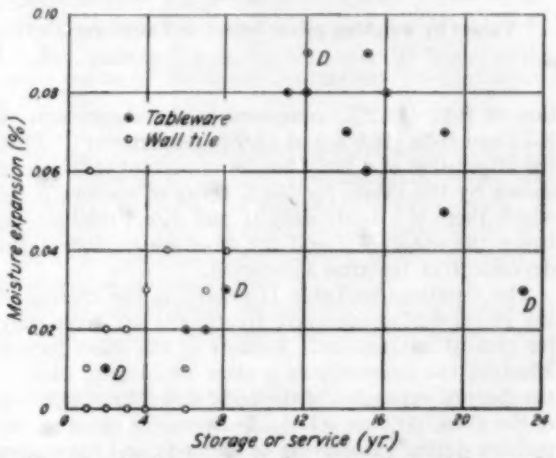

Fig. 1.—Moisture expansion occurring while specimens were in storage or in service; *D*, value for ware which had been in service.

An explanation for the exceptional behavior of body B-37, as compared to the other autoclaved specimens of the B series, would seem to entail a difference in chemical composition, but no such difference was indicated by the manufacturer. If the chemical composition is identical for all of the B-series specimens, then the reason for the difference may be the lower absorp-

* Received August 28, 1940.

[1] H. G. Schurecht, "Methods for Testing Crazing of Glazes Caused by Increases in Size of Ceramic Bodies," *Jour. Amer. Ceram. Soc.*, **11** [5] 271–77 (1928).

TABLE I

DESCRIPTION OF SAMPLES AND MOISTURE EXPANSION DURING STORAGE OR SERVICE

(Values for moisture expansion significant within ±0.01)

Laboratory designation	Sample	Glaze condition	Age (yr.)	Service	Approx. composition (%) Talc	Pyrophyllite	Clay	Feldspar	Flint	Water absorption* (%)	Moisture expansion (%)
A-34-CS	White wall tile	O. K.	6	Plant storage	34	4	50	2	10	12.6	0.00
A-34-N1	" " "	"	6	" "	"	"	"	"	"	14.8	.01
A-36-30	" " "	"	4	" "	"	"	"	"	"	12.3	.00
A-36-15	" " "	"	4	" "	"	"	"	"	"	14.3	.03
A-37-J	" " "	Unglazed	3	" "	"	"	"	"	"	16.0	.00
A-38-F	" " "	"	2	" "	"	"	"	"	"	16.7	.02
A-39-N2	" " "	O. K.	1	" "	17	"	47	"	20	18.3	.00
A-40-J	" " "	Unglazed	<1	" "	"	"	"	"	"	18.1	.00
B-33	" " "	O. K.	7	" "			60	9	31	16.9	.03
B-35	" " "	"	5	" "			"	"	"	15.0	.04
B-37	" " "	"	3	" "			"	"	"	11.2	.02
B-39	" " "	"	1	" "			"	"	"	15.6	.06
B-40	" " "	"	<1	" "			"	"	"	12.7	.01
C-32	" " "	"	8	" "	6		54	6	34	17.3	.04
C-34	" " "	"	6	" "	"		"	"	"	14.6	.00
C-36	" " "	"	4	" "	"		"	"	"	13.4	.00
C-38	" " "	"	2	" "	"		"	"	"	15.1	.00
C-40	" " "	"	<1	" "	"		"	"	"	15.5	.00
G-24	White, 7-in. plate	Crazed	16	Show case						9.6	.08
H-24	Buff sanitary	"	16	" "						10.4	.07
J-17-PE	White dish (English)	O. K.	23	Domestic use						8.8	.03
L-21-W5	White 5-in. plate	"	19	Plant storage			51	15	34	8.5	.04
L-21-W7	White 7-in. plate	"	19	" "			"	"	"	10.3	.07
L-25-WP	White platter	"	15	" "			"	"	"	14.3	.09
L-25-I7	Ivory 7-in. plate	"	15	" "			56	10	"	8.4	.06
L-26-W5	White 5-in. plate	"	14	" "			49	13	38	9.8	.07
L-28-I7	Ivory 7-in. plate	"	12	" "			56	10	34	11.4	.08
L-29-I7	" " "	"	11	" "			"	"	"	9.8	.08
L-32-IC	Ivory cup	"	8	Domestic use			52	"	38	7.0	.03
L-33-IP	Ivory platter	"	7	Plant storage			"	"	"	6.8	.02
L-34-W5	White 5-in. plate	"	6	" "			55	"	35	6.6	.02
X-28-W5	"	Crazed	12	Domestic use						8.8	.09
X-38-CE	White cup (English)	O. K.	2	" "						6.6	.01

* Values by weighing pieces before and after autoclaving in water for 5 hr. under steam pressure of 150 lb. per sq. in.

tion of B-37 (11.2%) compared to the absorptions of B-33 and B-39 (16.9% and 15.6%, respectively). That the absorption of a body has an important influence is shown by the values for the L series of specimens for which there is a fairly definite and direct relation between the absorption and the moisture expansion, independent of the time in storage.

The notations in Table II regarding the crazing of the glazes during autoclave treatments are given only for general information. Because of the other factors affecting the resistance of a glaze to crazing, such as the thermal expansion of the body and the composition of the glaze, no close relation between the moisture expansion during autoclaving of the body and the degree of crazing should be expected. It is also possible that a glaze may craze during an autoclave treatment and yet be entirely satisfactory in service if the body has an abnormally high thermal expansion at the temperatures reached in the autoclave.*

Body A-34-N1, for example, contracts thermally 0.20% between 100° and 200°C., whereas a typical glaze contraction would be about 0.06%. The compression thus set up in the glaze probably was sufficient to keep it in compression during several times the 0.01% of moisture expansion which had taken place at atmospheric temperatures during the past 6 years. At the temperatures reached in the autoclave, however, the high thermal expansion of the body removed this advantage of the glaze and brought about crazing (Table II). The thermal-expansion characteristics of the body and of the glaze, therefore, apparently are equally as important as the moisture expansion of the body for the determination of resistance to crazing in service.

The thermal expansion of each body was determined as a part of this investigation, and the values are recorded in Table III for future reference.

V. Summary

Eighteen samples of wall tile stored from 8 years to less than 1 year, and 15 samples of tableware of which 11 had been stored from 16 years to 6 years and 4 had been in service from 23 years to 2 years were tested to determine their water absorption and the moisture expansion which had taken place. Speci-

* In the autoclave used for these tests, a temperature of 183°C. is required to produce a steam pressure of 150 lb. per sq. in.

TABLE II

MOISTURE EXPANSION DURING AUTOCLAVE TREATMENT AND EFFECT OF AUTOCLAVING ON THE GLAZE

(Values significant within ±0.01)

Laboratory designation	Moisture expansion* (%) during autoclaving at 150 lb./sq. in. pressure			Type of crazing† after autoclaving	
	½ hr.	1½ hr.	5 hr.	1½ hr.	5 hr.
A-34-CS	0.04	0.06	0.08	Medium	Medium
A-34-N1	0.03	0.03	0.06	Coarse	Coarse
A-36-30				None	Coarse
A-36-15				None	None
A-37-J					
A-38-F					
A-39-N2				Coarse	Coarse
A-40-J					
B-33	0.07	0.08	0.08	Coarse	Medium
B-35				Fine	Fine
B-37	0.02	0.03	0.03	None	None
B-39	0.08	0.11	0.13	None	None
B-40				Fine‡	Fine‡
C-32				Coarse	Medium
C-34	0.00	0.00	0.00	None	None
C-36				Coarse	Medium
C-38				Coarse	Medium
C-40				None	None
G-24	0.11	0.14	0.17	d§	d§
H-24				d§	d§
J-17-PE	0.10	0.11	0.15	Coarse	Fine
L-21-W5			0.11	"	Medium
L-21-W7			0.14	"	Fine
L-25-WP	0.12	0.13	0.15	"	"
L-25-I7				"	"
L-26-W5				"	"
L-28-I7				"	"
L-29-I7					"
L-32-IC	0.07	0.08	0.10	None	None
L-33-IP				"	Fine
L-34-W5				"	Fine
X-28-W5				d§	d§
X-38-CE				Fine	Fine

* Values obtained with interferometer specimens which had been preheated to remove expansion that had taken place during storage or service.

† Observations made on glazed pieces which were autoclaved as received; any expansion taking place during this treatment is in addition to that which had taken place in service or storage.

‡ Glaze has a pronounced "egg-shell" finish.

§ Glaze crazed before tests.

mens of 12 samples were also subjected to three autoclave treatments of varying severity, and the resultant moisture expansions were determined.

The extremes in expansion noted were as follows: One tile showed an expansion of 0.04% after 8 years of storage, and 2 tile showed no measurable expansion after 6 years of storage. An expansion of 0.09% was shown by 2 samples of tableware after 15 years of storage and 12 years in domestic use, respectively, and another sample showed only 0.03% of expansion after 23 years in domestic use.

The values obtained indicate the need for additional data, particularly on samples which have been in actual service.

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TABLE III

LINEAR THERMAL EXPANSIVITIES OF BODIES DURING SECOND HEATING*

(Values to be multiplied by 10^{-6})

Laboratory designation	Expansion in the range of				
	Room temp.–100°C.	100°–200°C.	200°–300°C.	300°–400° C.	400°–500°C.
A-34-CS	7.0	10.4	9.0	6.8	8.2
A-34-N1	7.1	19.9	7.9	6.1	6.7
A-36-30	7.8	16.2	8.2	5.5	
A-36-15	7.4	16.5	10.2	6.5	7.2
A-37-J	8.4	18.0	9.3	6.8	6.9
A-38-F	8.5	18.0	10.2	7.4	7.8
A-39-N2	8.0	15.2	8.3	7.7	8.8
A-40-J	8.5	14.0	9.4	7.2	7.3
B-33	7.5	13.5	8.5	7.3	7.8
B-35	8.2	12.0	9.4	7.4	8.1
B-37	7.9	14.4	7.3	6.3	6.7
B-39	7.0	13.7	9.6	7.6	8.3
B-40	7.0	13.0	7.6	6.4	7.0
C-32	6.0	11.9	9.7	7.8	8.8
C-34	8.2	17.8	8.7	6.0	7.6
C-36	6.4	15.2	7.5	5.7	6.3
C-38	8.0	17.0	7.7	5.9	6.7
C-40	8.4	20.1	8.6	7.3	7.5
G-24	5.6	6.0	7.1	7.2	8.6
H-24	5.2	6.9	5.6	6.5	7.5
J-17-PE	5.5	9.3	8.8	8.4	10.2
L-21-W5	5.0	7.3	7.6	7.1	8.5
L-21-W7	5.1	6.6	6.8	7.4	9.4
L-25-WP	5.4	6.7	7.2	7.7	9.0
L-25-I7	5.4	7.0	7.1	7.5	9.0
L-26-W5	6.3	6.4	8.3	8.4	8.4
L-28-I7	5.0	7.0	7.7	7.9	8.8
L-29-I7	6.1	8.2	9.4	8.3	8.3
L-32-IC	5.7	6.7	7.0	7.7	9.1
L-33-IP	4.7	7.1	7.3	7.6	9.6
L-34-W5	5.8	8.9	7.3	7.1	8.3
X-28-W5	4.3	6.2	6.4	7.7	8.4
X-38-CE	6.1	7.4	7.5	7.6	9.6

* Expansion during second heating is the "true" expansion of the body; for details (see reference cited in footnote 1, p. 77).

THERMAL EXPANSION OF SILICATE FLUXES IN THE CRYSTALLINE AND GLASSY STATES*

By H. J. Orlowski and C. J. Koenig

Abstract

A general investigation was made of the thermal expansion of various silicate fluxes in the crystalline (anisotropic) and glassy (isotropic) states. The fluxes considered were ten feldspars, two nepheline syenites, anorthosite, aplite, and lepidolite.

I. Introduction

This investigation originated as the result of the failure of a glaze to "fit" a body when by all expectations it should have done so. Fundamental data were obtained to learn how thermal history might affect the thermal expansion of various silicate fluxes.

II. Review of Literature

No literature is available on the influence of thermal history on the thermal expansion of nepheline syenite, aplite, anorthosite, and lepidolite. Data have been presented on the influence of thermal history on potash- and soda-feldspar expansions, but no information could be found on the thermal expansion of feldspars when they are completely converted to the isotropic or glassy states.

Köhl[1] reports the expansivities of a Norwegian microcline feldspar, as a mineral (Feldspät verglüht), fired at Seger cone (SK) 08a, and of the feldspar (Feldspatglas)† fired at cone 6a for 2 hours (Fig. 1). When this feldspar was fired at cones 6a to 7 for 2 hours (between 10° and 500°C.) the coefficient of expansion was twice as great as when it was fired to cone 08a, that is, to the crystalline state. The variation in thermal expansion of this feldspar, progressing from the crystalline to the glassy states, is relatively large.

Geller and Creamer[2] report that the expansion of feldspars apparently is affected by the Na_2O-to-K_2O ratio and by the percentage of uncombined silica. The latter appears to be the dominating factor, but its influence decreases as the temperature to which the feldspar is fired is increased. No thermal-expansion data were presented on feldspars fired below cone 4 or above cone 14. Fourteen out of 19 feldspar samples contained more than 10% of free quartz.

Parmelee and McVay[3] indicate that high potash feldspars show a greater variation in thermal expansion with thermal-history differences between cones 4 to 12 than the high soda feldspars for the same differences. Feldspars, moreover, containing appreciable amounts of free quartz, showed a greater drop from the maximum expansion than those with a low amount of uncombined silica; the feldspar with the smallest amount of free quartz showed a maximum thermal expansion when it was fired to the highest temperature.

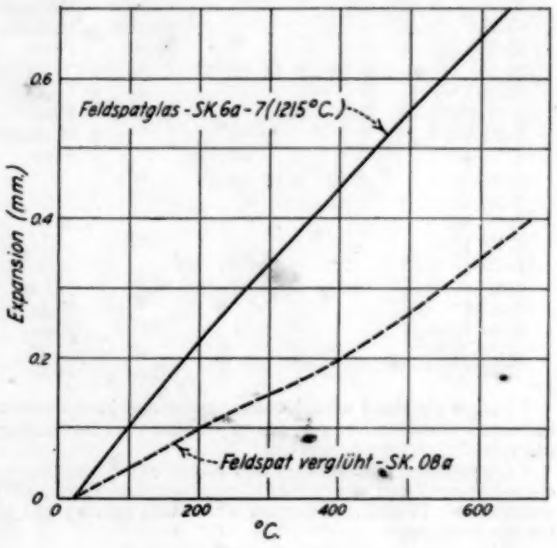

Fig. 1.

III. Procedure

Linear thermal expansions were determined for the crystalline (anisotropic) form of the 100% flux bodies, using a fused quartz expansion apparatus designed at the Bureau of Standards.[4]

The bars used for the test were rods, initially 8 in. long and 1/2 in. in diameter, formed by extruding the flux perpendicularly through a brass die. The flux was plasticized with a small amount of gum tragacanth. These bars were air dried on plaster of Paris slabs, allowed to bone dry in an electric oven at 230°F., and fired in an electric furnace at cone 06 so that the flux

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* Presented at the Forty-Second Annual Meeting, The American Ceramic Society, Toronto, Canada, April 10, 1940 (White Wares Division). Received April 10, 1940. Revised paper received October 11, 1940.

[1] H. Köhl, "Thermal Expansion and Some Other Physical Properties of Fine Porcelain as Affected by Composition and Firing Temperature," *Ber. deut. keram. Ges.*, **3** [6] 303–44 (1922); *Ceram. Abs.*, **5** [2] 60 (1926).

† Pure microcline decomposes to a glass and leucite crystals at 1170°C. and does not convert completely to a glass until it reaches a temperature above 1535°C.

[2] R. F. Geller and A. S. Creamer, "Investigation of Feldspar and Its Effect in Pottery Bodies," *Jour. Amer. Ceram. Soc.*, **14** [1] 30–71 (1931).

[3] C. W. Parmelee and T. N. McVay, "Investigation of Properties of Some Feldspars," *Univ. of Ill. Eng. Expt. Sta. Bull.*, No. 233, 50 pp. (1931); *Ceram. Abs.*, **11** [6] 376 (1932).

[4] (*a*) Peter Hidnert and W. T. Sweeney, "Thermal Expansion of Magnesium and Some of Its Alloys," *Bur. Stand. Jour. Research*, **1** [5] 771–92 (1928); R. P. 29; *Ceram. Abs.*, **8** [1] 65 (1929).

(*b*) American Ceramic Society Standards Report, *Jour. Amer. Ceram. Soc.*, **11** [6] 522–24 (1928).

particles were lightly bonded together. The flux particles in such specimens are arranged in different positions, with their crystallographic axes oriented in all directions. The thermal expansion of the specimen is assumed to be approximately equal to the average of the various axial-direction expansions of the crystalline individuals. Two determinations were made for each material and the average values are reported.

The interferometer,[5] with the interference method originated by Fizeau[6] and later developed by Pulfrich,[7] was used to measure the thermal expansion of the glass (isotropic) fluxes.

Owing to the difficulty of preparing glass-rod specimens suitable for use in the dilatometer, the interferometric procedure was used for these determinations. To correlate the two procedures, however, glass-rod specimens for nepheline syenite B and feldspar H (see Fig. 6) were prepared. The thermal expansions of these glass rods, determined by the dilatometer method, were compared to those obtained by the interferometric procedure.

To prepare these glass rods of varying lengths, representative samples of isotropic nepheline syenite B and feldspar H were ground in ball mills to −350-mesh. These powders were mixed with a small amount of water and 3-in. bars were formed by vibrating in vinyl acetate molds. After all of the water was vibrated from the nonplastics, the bars were removed, placed in a bed of powdered flint on refractory slabs, and fired in a gas furnace, the nepheline syenite B to 2060°F. and the feldspar H to 2250°F.

To prepare the three tripods to be placed between the fused quartz plates, representative samples of each of the fluxes were heated in refractory crucibles. A gas-fired Méker furnace was used, and the proper temperature was attained to convert these fluxes to glasses; for example, the feldspars were held for 1 hr. at cone 20; nepheline syenites, 1 hr. at cone 17; and anorthosite, 1 hr. at cone 23. The lepidolite and aplite were fired until they were completely fluid. Evidence of the isotropic or glassy* condition was checked with a petrographic microscope, the glasses were cooled in crucibles, and pieces were chipped from the center of the mass for use as interferometer specimens.

The specimens were annealed† by heating to 10°C. above their respective softening points at a relatively fast rate (600°C. in 2½ to 3 hr.), holding this temperature for 1 hr. to release strains, and cooling slowly to room temperature in 15 hr.*

The pieces of isotropic fluxes were ground on a lap wheel with silicon carbide powder into pyramidal shapes, approximately 0.25 in. high, and they were later adjusted with micrometer calipers exactly to the same height within 0.0001 in.

IV. Discussion

Figure 2 shows the expansion of nepheline syenites A and B in the isotropic and anisotropic states. The crystalline thermal expansion of nepheline syenite A is the highest of any of the silicate fluxes investigated. Nepheline syenite A also shows the least variation in thermal expansion with differences in thermal history. Nepheline syenite B, in both the crystalline and glassy states, shows a lower expansion than nepheline syenite A. The difference in expansion variation again is relatively small. No free quartz is present either in nepheline syenites A or B; this is shown by the absence of any hump of the curves in the vicinity of the α to β quartz inversion.

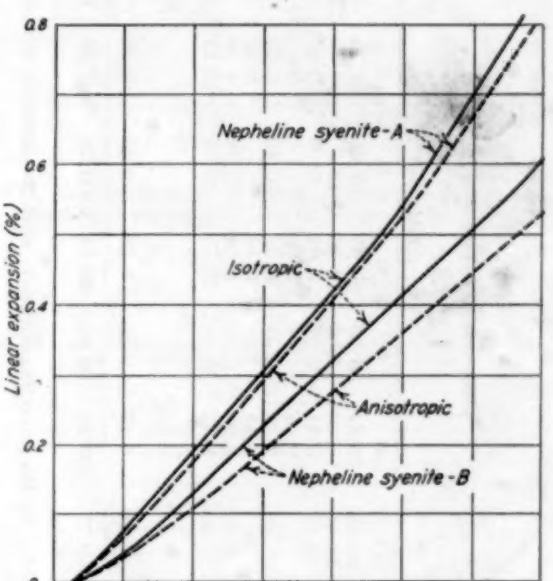

FIG. 2.—Nepheline syenite A: K_2O 4.06% and Na_2O 13.70%; nepheline syenite B: K_2O 5.01% and Na_2O 10.03%.

Figure 3 illustrates the expansion characteristics of a high and low soda feldspar. The expansions of these feldspars in the mineral and glassy conditions are respectively lower than those of the nepheline syenites, and the variation in thermal expansion is a little greater. Both contain free quartz, as shown by the change in slope of the curve around 573°C. The work of Parmelee and McVay[3] shows that soda feldspars containing quartz possess maximum expansion characteristics under intermediate firing conditions. Solution of the quartz at the higher temperatures would tend to lower the expansion of the glass.

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[5] (*a*) G. E. Merritt, "Application of Interferometer to Measurements of Thermal Dilatation of Ceramic Materials," *Bur. Stand. Sci. Paper*, No. 485, 17 pp. (March 7, 1924); *Ceram. Abs.*, **3** [6] 200 (1924).

(*b*) G. E. Merritt, "Interference Method of Measuring Thermal Expansion," *Bur. Stand. Jour. Research*, **10** [1] 59–76 (1933); R. P. 515; *Ceram. Abs.*, **12** [3] 129 (1933).

[6] M. Fizeau, "Report on Thermal Expansion of Solid Bodies," *Ann. chim. phys.*, [4] **8**, 335 (1866).

[7] C. Pulfrich, "Concerning the Abbé-Fizeau Dilatometer," *Z. Instrumentenk.*, **13**, 365 (1893).

* Theoretically, a small amount of leucite crystals may be present when potash feldspar is fired to cone 20 (1530°C.).

† These glasses obviously could not be annealed at the same time owing to their differences in transformation and softening points.

TABLE I
CHEMICAL ANALYSES OF FLUXES

Oxides	Nepheline syenites		Feldspars*									Lime feldspars		Lepidolite
	A	B	K	L	A	B	C	D	E	F	G	H	Aplite	Anorthosite	
SiO_2	48.92	60.24	69.12	68.40	72.84	68.30	66.04	67.68	64.70	67.84	65.33	65.90	60.64	50.68	52.89
Al_2O_3	31.69	24.05	18.04	19.40	15.40	17.90	18.76	18.87	19.50	17.27	19.27	18.70	23.69	30.67	26.77
Fe_2O_3	0.10	0.06	0.08	0.07	0.11	0.07	0.08	0.05	0.07	0.07	0.08	0.08	0.25	0.50	0.19
TiO_2	0.01	0.002			0.01		0.09		Tr.	Tr.	Tr.			0.07	
CaO	0.86	0.15	0.98	1.00	0.27	0.31	0.02	0.49	0.11	0.08	0.27	0.20	5.14	13.79	0.92
MgO	0.06	0.02	Tr.	Tr.	0.11		0.14		0.12	0.42	Tr.	Tr.	Tr.	0.42	0.31
Na_2O	13.70	10.03	5.18	9.30	2.93	2.87	3.56	2.78	4.19	2.15	2.67	1.70	6.28	3.40	0.13
K_2O	4.06	5.01	6.70	1.40	8.42	10.14	10.73	10.74	11.21	11.40	12.36	13.00	3.27	0.09	10.33
Li_2O															4.65
MnO_2															0.59
Fluorine															3.68
Ignition loss	0.43	0.46	0.30	0.20	0.27	0.26	0.22	0.17	0.36	0.52	0.16		0.74	0.20	0.66
Total	99.83	100.022	100.40	99.77	100.36	99.85	99.64	100.78	100.26	99.75	100.14	99.58	100.01	99.82	101.12

* Chemical analyses of the feldspars were furnished by the respective producers when the materials were obtained.

The thermal expansion behavior of four potash feldspars is shown in Fig. 4. Although their mineral expansions in general are lower than those of the high and low soda feldspars and of the nepheline syenites, the expansion characteristics of these potash-feldspar glasses result in a much wider variation in thermal expansion with differences in thermal history. These potash feldspars also contain appreciable amounts of free quartz as evidenced by their large quartz inversions. It is therefore reasonable to assume that their isotropic expansions would have been higher had it not been for the presence of relatively large amounts of free quartz. Feldspars A and B, with greater amounts of free quartz, show less expansion variation than feldspars C and D, which contain less free quartz.

FIG. 3.—Feldspar K: K_2O 6.70% and Na_2O 5.14%; feldspar L: K_2O 1.40% and Na_2O 9.30%.

FIG. 4.—Feldspar A: K_2O 8.42% and Na_2O 2.93%; feldspar B: K_2O 10.14% and Na_2O 2.87%; feldspar C: K_2O 10.73% and Na_2O 3.56%; feldspar D: K_2O 10.74% and Na_2O 2.78%.

Potash feldspars E, F, G, and H (Fig. 5) have wider variations in thermal expansion than any of the other silicate fluxes included in this study. They also contain little or no free quartz so that their isotropic expansions are essentially those of true potash feldspars in the glassy state. Potash feldspar H in the isotropic state has even a higher expansion than that of isotropic nepheline syenite A. Referring again to the work of Parmelee and McVay,[3] the potash feldspar lowest in free quartz content shows a maximum thermal expansion at the highest temperature to which it was fired.

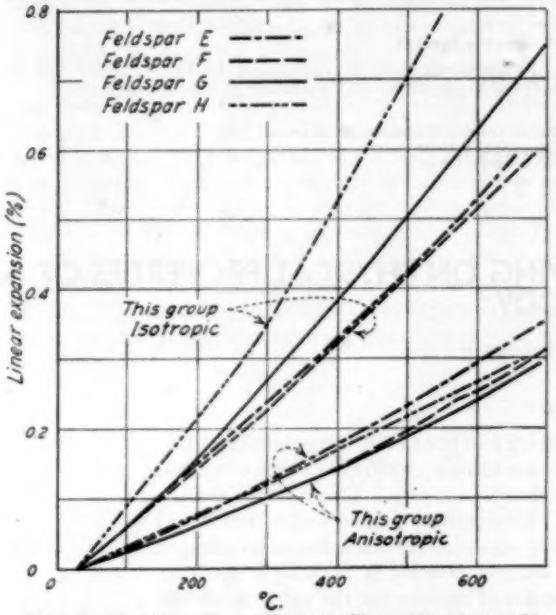

FIG. 5.—Feldspar E: K_2O 11.21% and Na_2O 4.19%; feldspar F: K_2O 11.40% and Na_2O 2.15%; feldspar G: K_2O 12.36% and Na_2O 2.67%; feldspar H: K_2O 13.0% and Na_2O 1.70%.

In Fig. 6, thermal expansion values were obtained separately by the extensometer method on 3-in. bars of the isotropic forms of potash feldspar H and nepheline syenite B, and these values were compared with those obtained by the use of the interferometer. Determinations were also made on 1-in. and 4-in. bars, and the values were in close agreement with those reported for the 3-in. bars.

The expansion of aplite (Fig. 7) in the crystalline form is near that of the potash feldspars, which are low in free quartz, whereas the thermal expansion of the glass formed by melting aplite is lower than that of the potash feldspars.

Figure 7 also illustrates the thermal expansion of anorthosite in the crystalline and partially fused states. Crystalline anorthosite has about the same expansion as crystalline nepheline syenite B. Because of its refractoriness no expansion values were determined in its glass form. This material is predominately composed of bytownite ($Ab_{20}An_{80}$), which is molecularly a solid solution of 20% of albite ($Na_2O \cdot Al_2O_3 \cdot 6SiO_2$) and 80% of anorthite ($CaO \cdot Al_2O_3 \cdot 2SiO_2$).

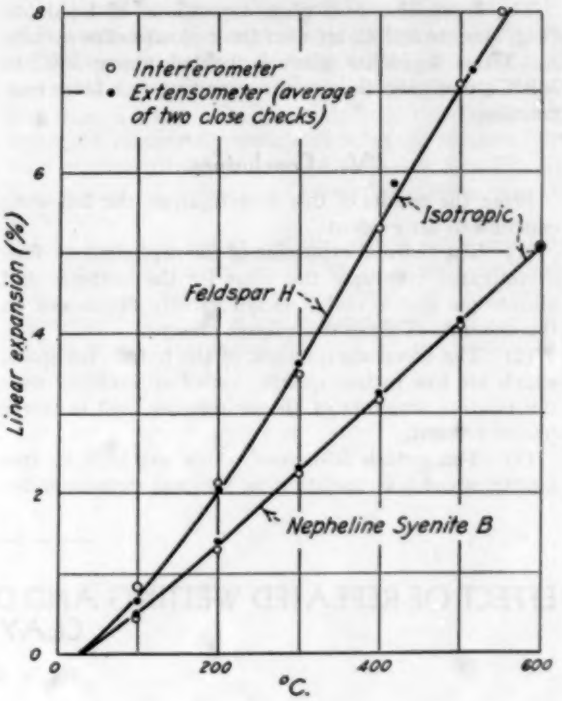

FIG. 6.—Comparison of thermal-expansion values obtained by interferometer and extensometer (3-in. bar).

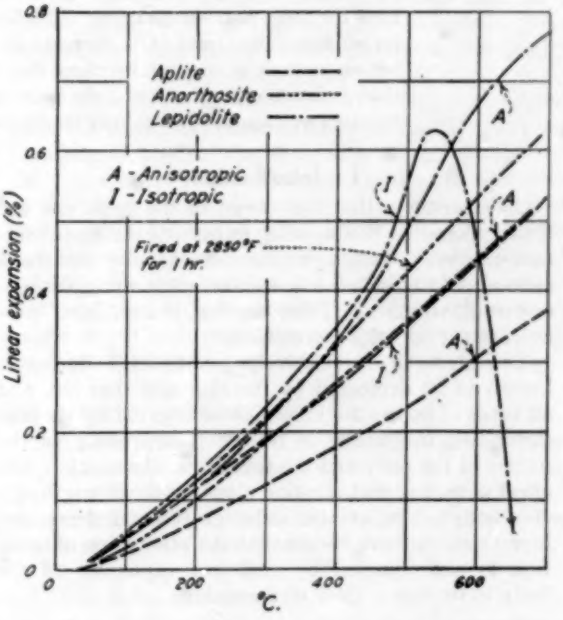

FIG. 7.—Aplite: K_2O 3.27%, Na_2O 6.28%, and CaO 5.14%; anorthosite: K_2O 0.09%, Na_2O 3.40%, and CaO 13.79%; lepidolite: K_2O 10.33%, Na_2O 0.13%, Li_2O 4.65%, and Fl_2 3.68%.

The crystalline and glass expansions of lepidolite (Fig. 7) up to 500°C. are near those of nepheline syenite A. When lepidolite glass is heated above 530° to 540°C., devitrification occurs, resulting in a large contraction.

V. Conclusions

From the results of this investigation, the following conclusions are evident:

(1) The thermal expansion of the nepheline syenites investigated is nearly the same for the isotropic and anisotropic states, and it is not greatly dependent on the amounts of these two phases present.

(2) The thermal expansion of the potash feldspars, which are low in free quartz, varies appreciably with the relative amounts of the anisotropic and isotropic phases present.

(3) The potash feldspars, which are high in free quartz, show less variation in thermal expansion between the crystalline and glassy conditions than do the potash feldspars that have a low amount of free quartz.

(4) The thermal expansions of the high and low soda feldspars in the crystalline form are higher than those of the potash feldspars and lower than those of the nepheline syenites.

(5) Aplite, in the crystalline form, has a thermal expansion near that of the potash feldspars that are low in free quartz, whereas its expansion as a glass is lower than that of the potash feldspars.

(6) Lepidolite glass, which has a relatively high thermal expansion up to 530°C., devitrifies between 530° and 540° C., resulting in a large contraction.

Acknowledgment

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EFFECT OF REPEATED WETTING AND DRYING ON PHYSICAL PROPERTIES OF A CLAY BODY*

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Abstract

Specimens of fine-grained, red-firing clay, which had been fired to temperatures corresponding to various stages of vitrification, were subjected to 200 cycles each of wetting at 100°F. and drying at 100°F. and 60% of relative humidity. This treatment, simulating weathering in mild climates, caused (1) a permanent gain in weight which was greater for the softer specimens; (2) a moisture expansion for the softer specimens but none for those near vitrification; (3) a fairly uniform decrease in modulus of elasticity for all specimens; and (4) a decrease in modulus of rupture for the softer specimens but an increase in strength for those that were completely vitrified. The data indicate that moisture expansion and a decrease in strength of soft-fired clay bodies, caused by repeated wetting and drying, may be eliminated by proper vitrification.

I. Introduction

Clay products that are stored in the open and are thus exposed to the weather frequently develop "surface checks." Although these checks may not be a serious defect, in some instances such ware also decreases in strength. There are few, if any, data, however, to support this contention.

The strength of relatively porous clay bodies is known to be decreased by freezing and thawing, and all types of bodies are known to be affected by thermal shock, the magnitude of the effect depending on the nature of the body and the severity of the shock. The effect of moisture absorption alone on the strength of a clay body is not known, although recent independent investigations have shown that the absorption of moisture is accompanied by sufficient expansion of the body to rupture a glaze on its surface.

Ware stored in the open, where the climate is more or less severe, might be expected to be subjected to any or all of the foregoing conditions at some time during the year. During the summer, however, and in mild climates, the principal weathering effect would be repeated wetting and drying. Because the absorption of moisture is accompanied by expansion, an internal stress probably would exist and a repetition of this condition would produce a "fatigue" effect and gradually decrease the strength of the body.

The purpose of the present study, therefore, was to determine only the effect of repeated wetting and drying on the physical properties of a clay which had been fired over a range of temperature corresponding to different stages of vitrification.

(1) Field Covered

A fine-grained, red-firing clay that was known to have developed "surface checks" was selected for the tests. The specimens, which were soft fired, vitrified, and overfired, were subjected to 200 cycles of wetting at 100°F.

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and drying at 100°F. and 60% of relative humidity. The percentage of porosity, modulus of elasticity, modulus of rupture, moisture expansion, and permanent gain in weight were determined after 50, 100, 150, and 200 cycles, and the results were compared with the properties of the specimens determined immediately after firing.

II. Procedure

(1) Preparation of Specimens

Two types of specimens were prepared, one for the determination of expansion and modulus of elasticity and the other for the determination of permanent gain in weight and modulus of rupture.

The expansion specimens were 1- by 1- by 12-in. clay bars in which fixed points for measurement were provided by metal plugs. These were set in Wood's metal in holes that were drilled in the bars before firing. Gauge points 10 inches apart, were drilled in the plugs for the measurement of expansion and contraction with a Whittemore strain gauge which may be read to $^1/_{10,000}$ inch. The specimens used for the other tests were ordinary 1- by 1- by 6-in. bars.

Ten 12-in. expansion specimens and fifty 6-in. specimens were each fired to cones 09, 06 to 05, 1 to 2, 4 to 5, and 7 to 8.

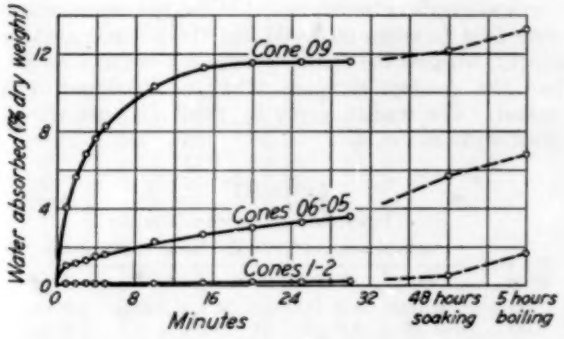

FIG. 1.—Absorption of water by specimens fired at different temperatures.

(2) Test Procedure

The properties of some of the specimens were measured immediately after they were drawn from the kiln; the remaining specimens were immersed in a thermostatically controlled water bath at 100°F. and were dried in a Carrier laboratory drier, which was provided with automatic temperature and humidity control, at 100°F. and 60% of relative humidity. This cycle was repeated 200 times.

The same set of specimens was used throughout the test for moisture expansion and modulus of elasticity measurements. For the other tests, groups of 6-in. specimens were removed and dried at 212°F., weighed to determine the gain in weight, and then broken to obtain the modulus of rupture.

(3) Length of Immersion and Drying Periods

The rate of saturation of the specimens was determined by noting their increase in weight when they were suspended in water for 30 minutes, for 48 hours, and after 5 hours of boiling. Although the specimens were not completely saturated after 30 minutes, the rate of absorption had become very slow (see Fig. 1). The period of immersion selected therefore was 30 minutes.

The length of the drying period was determined by measuring the loss of weight of specimens over a 6-hour period. Although the specimens had not reached equilibrium, the rate of loss had decreased and a drying period of $5^1/_2$ hours was selected for the tests. The results are shown in Fig. 2.

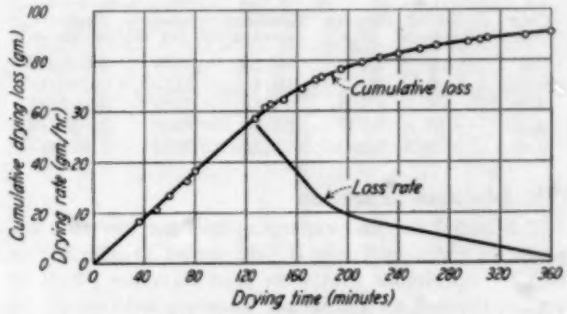

FIG. 2.—Determination of length of drying cycle for specimens of highest porosity.

(4) Expansion Measurements

The specimens used for the expansion tests were measured at 70°F., and all expansions resulting from experimental treatment were referred to the length found in the initial measurement.

All of the specimens expanded when they were heated from the initial temperature of 70°F. to the test temperature of 100°F., the expansion being recorded as that after zero cycles. The specimens were measured while they were still immersed in the water bath and again after they were dried at 100°F. and 60% of relative humidity. These two measurements differed only slightly and, because it was possible to maintain the specimens at a more nearly constant temperature in the water bath than after they were removed from the drier, the former measurements are reported.

(5) Modulus of Elasticity

Data on modulus of elasticity were obtained by loading oven-dried specimens at the center of a 10-in. span with a 100-lb. load and measuring the net deflection with three $^1/_{10,000}$-in. dials, one at the center of the span and one over each bearing.

(6) Modulus of Rupture

The tests on modulus of rupture were made with a standard Olsen cross-breaking machine in which the 1- by 1- by 6-in. specimens were loaded to failure in the center of a 5-in. span. The breaking load was meas-

ured by a beam weight, which was advanced continuously by an electric motor, the beam being balanced by application of pressure by a hand screw.

III. Results

(1) Initial Properties

Table I gives the initial properties of the specimens, which show a uniform decrease in porosity from about 29% at cone 09 to 0.7% at cones 4 to 5, followed by an increase to about 13% at cones 7 to 8 because of overfiring; corresponding changes in shrinkage, modulus of rupture, and modulus of elasticity are also indicated.

TABLE I

INITIAL PROPERTIES OF SPECIMENS

Cone No.	No. of specimens	Porosity (%)	Firing shrinkage (volume)	Modulus of rupture (lb./sq. in.)	Modulus of elasticity (lb./sq. in.)
09	9	28.9	6.28	2659	3,805,000
06–05	9	20.7	16.11	3217	6,080,000
1–2	8	4.3	22.13	3903	9,192,000
4–5	10	0.7	23.83	3908	9,957,000
7–8	9	12.9	12.32	2653	7,435,000

(2) Moisture Expansion

The initial thermal expansion and the moisture expansions given in Table II, are shown graphically in Fig. 3. Specimens that were fired to cones 1 to 2, or higher, showed no significant moisture expansion, the slight variations from the initial lengths being within experimental error. Specimens, fired at the two lower temperatures, that is, to cones 09 and 06 to 05, had a total moisture expansion of 0.043 and 0.037%, respectively. The moisture expansion in both cases increased rapidly at first, but the expansion rate decreased slowly with the increasing number of cycles of wetting and drying. Although the rate of expansion was decreasing, the specimens were still expanding when they were measured after the 200th cycle.

TABLE II

EXPANSION PRODUCED BY REPEATED WETTING AND DRYING

No. of cycles	Expansion (%) for specimens fired at cones indicated: 09	06–05	1–2	4–5	7–8
0*	0.013	0.013	0.012	0.013	0.009
1	0.015	0.015	0.013	0.013	0.009
5	0.028	0.022	0.011	0.011	0.008
10	0.031	0.026	0.011	0.012	0.009
15	0.034	0.027	0.011	0.011	0.008
20	0.034	0.027	0.009	0.010	0.007
25	0.036	0.028	0.010	0.010	0.007
30	0.035	0.028	0.009	0.010	0.007
35	0.037	0.029	0.009	0.009	0.006
40	0.038	0.030	0.010	0.010	0.007
50	0.042	0.031	0.010	0.010	0.007
100	0.048	0.041	0.013	0.013	0.010
150	0.051	0.044	0.013	0.010	0.009
200	0.056	0.050	0.013	0.011	0.010

* Initial expansion on heating specimens from atmospheric temperature of 70° to 100°F. and at 60% of relative humidity, the conditions under which they were dried after each wetting; values for "zero cycles" are to be subtracted from other values in the table to obtain net expansion caused by wetting and drying.

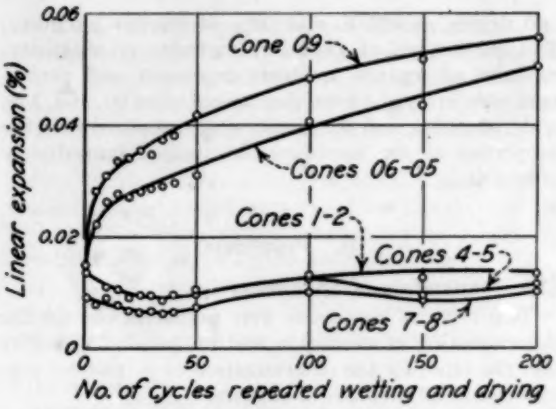

FIG. 3.—Clay body fired at different temperatures showing percentage of linear expansion.

(3) Permanent Gain in Weight

All specimens increased in weight, the smaller gains occurring for the specimens that were fired above cones 1 to 2. The gain in weight in all cases tended to pass through a maximum and then to decrease with an increase in the number of wetting and drying cycles. The decrease, after passing the maximum, was more pronounced in the softer specimens, suggesting the possibility that these specimens might have lost some weight by repeated handling or by solution. This was borne out further by the fact that the specimens which were fired to cones 06 to 05 had the greatest gain in weight, whereas the softer specimens, fired at cone 09, had the greatest decrease after the maximum was passed. The results, given in Table III, are shown graphically in Fig. 4.

TABLE III

PERMANENT GAIN IN WEIGHT

No. of cycles	Gain in weight (%) for specimens fired at cones: 09	06–05	1–2	4–5	7–8
50	−0.023	+0.11	+0.04	+0.026	+0.04
100	+0.14	+0.38	+0.16	+0.017	+0.024
150	+0.26	+0.38	+0.12	+0.11	+0.14
200	+0.03	+0.21	+0.11	+0.10	+0.13

(4) Modulus of Elasticity

The modulus of elasticity of all specimens decreased as a result of the wetting and drying treatment. The major decrease occurred during the first 50 cycles; the changes after that were small and somewhat irregular. On the basis of the average percentage decrease for all specimens fired at any one temperature, the greatest change caused by wetting and drying occurred in the specimens fired at cone 09. These specimens showed a decrease of 14.6% in modulus of elasticity; this decrease lessened somewhat as the firing temperature increased as indicated by a decrease in modulus of 10.7% for specimens fired at cones 1 to 2. At the vitrification point or when the specimens were overfired, however, the effect of wetting and drying again increased, which is indicated by the decrease in modulus of 13.9% for specimens fired at cones 7 to 8.

All of the decreases in the modulus of elasticity, as compared with the initial value for the specimens when they are drawn from the kiln, are statistically significant.

The results are shown in Table IV and in Fig. 5.

(5) Modulus of Rupture

All of the modulus of rupture values that were significant indicated that repeated wetting and drying decreased the strength of those specimens which were fired at cones 09, 06 to 05, and 1 to 2 with a range in porosity from 28.88 to 4.35%, as well as the specimens which were overfired at cones 7 to 8. The strength of the specimens that were fired at cones 4 to 5 and having a porosity of 0.66% was increased by the wetting and drying treatment. As in the case of modulus of elasticity, the progressive effect of the increased number of cycles was somewhat irregular, the major change occurring during the first 50 cycles.

TABLE IV

EFFECT OF REPEATED WETTING AND DRYING ON MODULUS OF ELASTICITY

No. of cycles	Modulus of elasticity (lb./sq. in.)	Probable error (%)	No. of specimens	Decrease (%)
	Specimens fired to cone 09			
0*	3,805,000	1.86	9	
50	3,208,000	2.31	9	15.7
100	3,358,000	1.17	9	11.7
150	3,206,000	1.31	9	15.7
200	3,214,000	1.49	9	15.5
	Fired to cones 06 to 05			
0	6,080,000	2.79	9	
50	5,304,000	2.50	9	12.8
100	5,379,000	2.23	9	11.5
150	5,129,000	2.48	9	15.6
200	5,160,000	2.47	9	15.1
	Fired to cones 1 to 2			
0	9,192,000	1.12	8	
50	8,014,000	1.41	8	12.8
100	8,367,000	1.30	8	8.9
150	7,965,000	1.35	8	13.3
200	8,462,000	5.57	8	7.9
	Fired to cones 4 to 5			
0	9,957,000	2.31	10	
50	8,655,000	2.29	10	13.1
100	9,050,000	1.54	10	9.1
150	8,478,000	1.56	10	14.8
200	8,487,000	1.61	10	14.7
	Fired to cones 7 to 8			
0	7,435,000	1.39	9	
50	6,480,000	2.71	9	12.9
100	6,540,000	1.63	9	12.0
150	6,531,000	1.06	9	12.1
200	6,053,000	3.23	9	18.5

* Zero (0) cycle indicates the conditions of the specimens as they were drawn from the kiln.

The results, including a calculation of their statistical significance, are given in Table V, and the general trends are shown in Fig. 6.

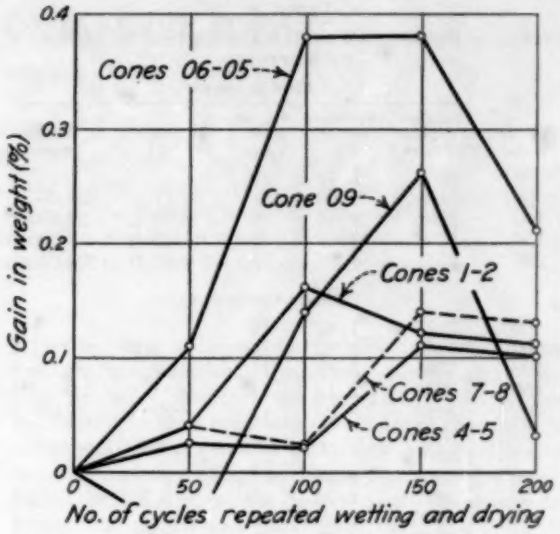

FIG. 4.—Permanent gain in weight.

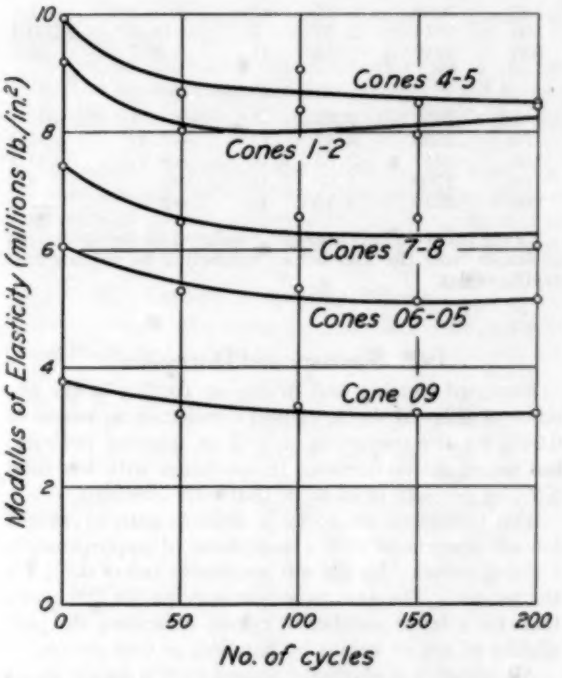

FIG. 5.—Effect of repeated wetting and drying on modulus of elasticity of clay body.

The greatest decrease in strength usually occurred in those specimens having higher porosity. As the firing temperature increased and porosity decreased, the effect on strength diminished until vitrification was reached. The strength of the vitrified body was increased by repeated wetting and drying at 100°F.

TABLE V

EFFECT OF REPEATED WETTING AND DRYING ON MODULUS OF RUPTURE

No. of cycles	Modulus of rupture (lb./sq. in.)	Probable error (%)	No. of specimens	Change (%)	Significance
		Fired to cone 09			
0*	2659	1.42	12		
50	2191	1.60	11	−17.6	20,000:1
100	2285	1.48	9	−14.0	20,000:1
150	2238	3.09	7	−15.8	3,200:1
200	2341	1.63	11	−11.9	20,000:1
		Fired to cones 06 to 05			
0*	3217	1.82	12		
50	3163	2.62	11	− 1.7	1:1
100	3261	3.56	11	+ 1.3	1:1
150	3252	2.12	11	+ 1.1	1:1
200	2462	2.63	11	−23.4	20,000:1
		Fired to cones 1 to 2			
0*	3903	2.17	11		
50	3677	1.76	10	−5.7	5:1
100	3696	2.30	10	−5.3	3:1
150	3601	2.42	11	−7.7	10:1
200	3535	2.37	11	−9.4	22:1
		Fired to cones 4 to 5			
0*	3908	2.32	12		
50	4321	1.87	11	+10.5	45:1
100	3969	2.37	11	+ 1.5	1:1
150	4614	2.26	9	+18.0	2,200:1
200	4249	1.58	11	+ 8.7	22:1
		Fired to cones 7 to 8			
0*	2653	2.37	11		
50	2588	3.47	11	−2.4	1:1
100	2417	2.65	10	−8.9	11:1
150	2709	1.98	11	+2.1	1:1
200	2714	2.15	11	+2.3	1:1

* Zero (0) cycle indicates the condition of the specimens as drawn from the kiln before subjecting to wetting and drying cycles.

IV. Summary and Discussion

Repeated wetting and drying at 100°F., in the absence of thermal shock, caused a moisture expansion of 0.04% for the specimens of 20% or more of porosity, but no expansion occurred in specimens with less than 4.5% of porosity or in those that were overfired.

The treatment produced a definite gain in weight for all specimens with a maximum of approximately 0.4% of porosity for the soft specimens and of 0.1% for the harder. The gain in weight was less for 200 cycles than for a fewer number of cycles, indicating the possibility of loss of weight by handling or by solution.

All modulus of elasticity values were reduced about 13% by the treatment. The major effect occurred during the first 50 cycles.

All modulus of rupture values were reduced by the treatment except those for the vitrified body which had a porosity of 0.66% and an increase in modulus of rupture of 12%. The strength of the softest specimens (porosity of approximately 29%) was decreased about 15%; the strength of specimens with an intermediate range of porosity was not decreased so much but the differences were also less significant.

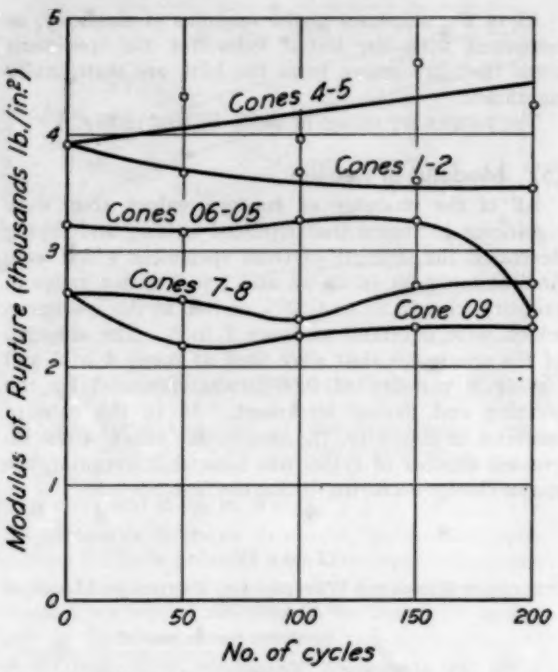

FIG. 6.—Effect of repeated wetting and drying on modulus of rupture of a clay body.

The increase in strength of the vitrified specimens might be explained by the release of strains set up in the more or less glassy, fired body in the initial cooling.

The results also indicate that soft bodies might decrease in strength and vitrified bodies might increase in strength after they are drawn from the kiln.

V. Conclusions

The repeated wetting and drying of a clay body, in the absence of freezing and thawing or of thermal shock, may produce permanent gain in weight and moisture expansion. These effects decrease when the firing temperature is increased and the porosity of the body is decreased. The treatment may also produce a fairly constant decrease in modulus of elasticity and a variable decrease in modulus of rupture; the latter is greater in the softer bodies and changes to an increase in strength for a vitrified body.

The tendency of soft, fired clay bodies to decrease in strength in open storage may be eliminated by proper vitrification.

Acknowledgment

The experimental data were obtained in the laboratories of the Department of Ceramic Engineering at the University of Illinois in 1931 as the result of a cooperative agreement between the Engineering Experiment Station and the Clay Products Association of Chicago, Ill. Acknowledgment is made to R. K. Hursh, under whose general supervision the work was started; to C. W. Parmelee, under whom the work was completed; to George H. Duncombe, Jr., of the Association staff, for helpful discussion of the problem; and to C. L. Thompson for assistance in completing the calculations.

6 HIGH STREET
WESTBORO, MASSACHUSETTS

PHYSICAL PROPERTIES OF MASSIVE TOPAZ*

By J. L. Stuckey and J. J. Amero

Abstract

Tests on the deposit of massive topaz in Chesterfield County, South Carolina, show that the mineral has a P.C.E. of 40 and a low permanent expansion. Most of the fluorine and water are driven off between 850° and 900°C. The fluorine, however, carries off with it some of the iron and considerable silica. The physical properties of a fire-clay refractory in which different amounts of topaz are used to replace flint fire clay have also been investigated.

I. Introduction

A deposit of massive topaz occurs as part of the gold-bearing lode at the Brewer Mine, which is situated about 3 miles northeast of Jefferson, Chesterfield County, South Carolina (see Fig. 1).

The formula for topaz, $Al_2O_3 \cdot SiO_2(F,OH)_2$, suggests that it might possess properties which would make it useful as a refractory material. Because no information was available on its characteristics after firing, a preliminary study was made of its physical properties after it had been fired to various temperatures. Additions of topaz were made to a flint fire-clay refractory to determine its effect on P.C.E. and on the properties after it was fired to cone 14.

Fig. 1.—Map of South Carolina showing location of deposit at Brewer Mine.

II. Review of Literature

As far as is known, the Brewer Mine is the only deposit of topaz of considerable size to be reported. Pardee, Glass, and Stevens[1] made an extensive study of the deposit in 1937 and reported on the geology, optical properties, and chemical composition of this mineral.

The Brewer gold mine was opened before the War between the States. Pardee and his associates[1] give the following description:

> In the course of intermittent mining operations during the last hundred years, a superficial placer deposit has been largely stripped from an area of 20 or 30 acres and numerous pits have been excavated, one of them 300 ft. across and 140 ft. deep. . . . . A rock composed almost exclusively of very fine-grained topaz forms a considerable part of the lode northwest of the Brewer pit. Its exposures in place occupy an area about 25 ft. wide and 50 ft. or more long, but a greater extent of the body is indicated by the distribution of "float" on the slope above the outcrop.

Rock samples, taken at various distances in a 400-ft. adit on the north side of the large pit at the same elevation as the bottom, show high topaz content, many of them exceeding 90%.

Pardee indicates that the texture of topaz is similar to that of flint or chert and that it has a waxy luster; its hardness is about 7, which is less than that for normal topaz.

The specific gravity, determined by the water-immersion method, was 3.509. Some of the weathered fragments show the red staining of iron oxide, but chemical analysis reveals only a small iron content.

III. General Properties After Firing

An analysis of the topaz used in this investigation is given in Table I. The P.C.E. of this material was 40.

Table I

Chemical Analyses of Topaz

	(1)*	(2)†
SiO_2	33.00	32.70
Al_2O_3	56.76	57.80
Fe_2O_3	Trace	0.75
H_2O-	0.04	Not reported
H_2O+	2.67	" "
F_2	13.23	14.20
	105.70	105.45
$-0 = 2F$	5.57	5.98
	100.13	99.47

*Analysis reported by Pardee and associates.
†Analysis of material used in this investigation.

(1) Effect on Physical Properties

Samples of the topaz, dried at 110°C. and ground to pass a 65-mesh Tyler sieve, were heated in Alundum crucibles at 100°C. intervals to between 200° and 1600°C. The temperature, in each instance, was main-

*Presented at the Forty-Second Annual Meeting, The American Ceramic Society, Toronto, Canada, April 9, 1940 (Refractories Division). Received April 9, 1940.

[1] J. T. Pardee, J. J. Glass, and R. E. Stevens, "Massive Low-Fluorine Topaz from Brewer Mine, S. C.," *Amer. Mineralogist*, **22** [10] 1058–64 (1937).

tained as nearly constant as possible for 10 hours. A small electric furnace with relay control was used for temperatures up to 1000°C., and a small gas-fired muffle was used for the higher temperature range. The temperature did not vary more than ±5°C. in the electric furnace or more than ±10°C. in the muffle furnace.

Figure 2 shows the progressive loss in weight of the fired topaz. The greatest loss occurs between 850° and 900°C., and it is accompanied by the evolution of a white vapor. After a number of firings, a thin white film of very fine almost colloidal silica was deposited on the cooler portions of the muffles. At 1300°C., the curve begins to level off and there is practically no loss in weight.

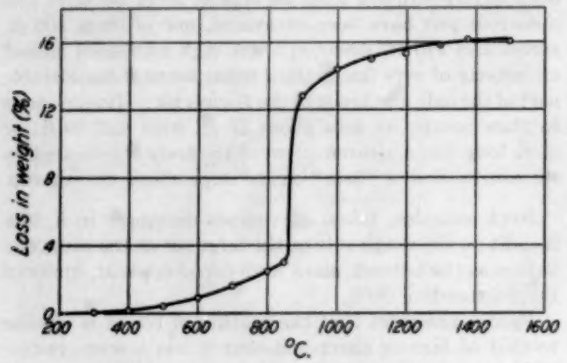

FIG. 2.—Loss in weight on heating.

Figure 3 shows the results of true specific gravity determinations on fired samples, made by the pycnometer method. The general course of this curve is consistent with the weight-loss curve. The most rapid change occurs between 800° to 900°C. when the specific gravity decreases from 3.364 and 3.085. Some increase, probably caused by the formation of a eutectic glass, was observed at 1600°C.

The color of the unfired ground topaz and that of the fired samples was buff to light brown up to 850°C.; the samples, however, fired to a pure white at 900°C. and higher.

(2) Mineralogical Changes

Mineral identification with a polarizing microscope was difficult owing to the massive structure of the topaz. Examinations were made on the sections of fired chips and after powder immersion in index liquids. At 1100°C., and particularly above this temperature, some material was observed whose properties corresponded to those of mullite.

For more positive identification, X-ray diffraction patterns were made on samples which had been heated above 1000°C. As shown by both the X-ray and petrographic study, the untreated material was practically pure topaz. Mullite was present as the principal constituent at 1100°C. as well as small amounts of cristobalite and topaz. The mullite content increased in samples heated above 1100°C. until, at 1500°C., the material was practically all mullite.

(3) Changes in Chemical Composition

Chemical analyses were made of samples fired to 1000° and 1500°C. Table II shows that there is a loss of silica and an increase in alumina after it is fired. The fluorine, eliminated at 850° to 900°C., when the topaz molecule is broken down, evidently combines with and removes some of the silica and iron.

TABLE II

CHANGES IN CHEMICAL COMPOSITION OF FIRED TOPAZ

	Untreated	At 1000°C.	At 1500°C.
SiO_2	32.70	32.10	29.85
Al_2O_3	57.80	66.41	69.21
Fe_2O_3	0.75	0.79	0.82
F_2	14.20	0.80	0.12
	105.45	100.10	100.00
$-O = 2F$	5.98	0.34	0.05
	99.47	99.76	99.95

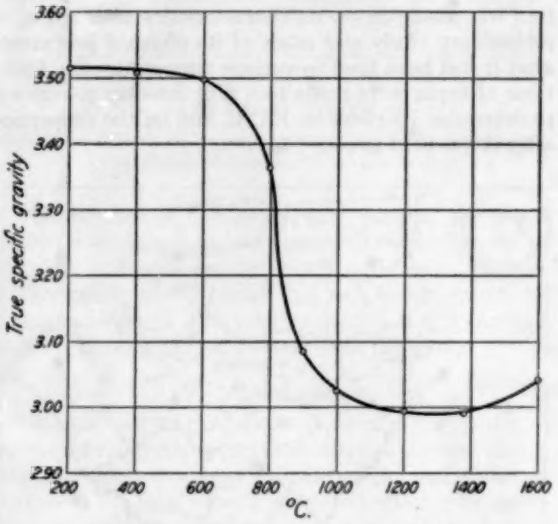

FIG. 3.—Change in specific gravity on heating.

IV. Value of Topaz in a Refractory Body

The fact that topaz has a high fusion point and forms mullite at relatively low temperatures indicates that it might be useful in a refractory body. The refractory fire-clay body consisted of 80% of high-grade Kentucky flint fire clay and 20% of plastic clay. Various replacements of the nonplastic portion of the body amounting to 33.3, 66.6, and 100% were studied. These mixes were fired to cone 14 and were tested for P.C.E. properties, thermal expansion, hot load deformation, and spalling resistance. The tests were conducted according to the A.S.T.M. specifications.

(1) Grain Size

The fire clay and the topaz were ground to pass 10-mesh. A series of replacements was also made in which the topaz was added as −65-mesh material, and the sieve analyses are given in Table III.

TABLE III

SIEVE ANALYSES OF MATERIALS

Sieve No.	Topaz (−10-mesh)	Fire clay (−10-mesh)	Topaz (−65-mesh)
10	0.2	0.0	
16	28.5	23.3	
20	11.0	10.9	
28	17.6	15.8	
35	12.8	12.0	
48	9.6	9.5	
65	7.3	6.7	1.9
80	3.0	3.4	4.8
100	1.6	2.9	10.0
150	2.0	4.5	18.6
200	1.5	3.8	32.4
−200	4.1	6.9	32.0
	99.2	99.7	99.7.

(2) Preparation of Specimens

All specimens were formed in a hydraulic press at a pressure of 2500 lb. per sq. in. They were dried first at 70°C. for 12 hr. and then at 140°C. for 12 hr.

(3) Thermal Expansion

The thermal expansion was determined on a specimen composed of topaz, ground to pass 10-mesh and formed in a press at 2500 lb. per sq. in. Figure 4 shows the results of this determination.

The thermal expansion of crude topaz is small, amounting only to 1.210% at 1200°C. The permanent expansion, 0.758%, constitutes a large part of the total expansion.

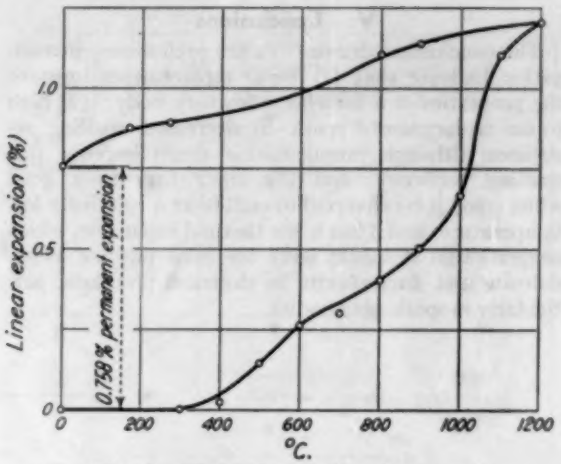

FIG. 4.—Thermal expansion of topaz.

(4) Dry and Fired Properties

The properties of the bodies, dried and fired to cone 14, as well as their pyrometric cone equivalents, are given in Table IV. Topaz replacements raised the P.C.E., reduced the firing shrinkage, and increased the resistance to deformation under load. The spalling loss of body No. 1, which contained the largest amount of topaz, however, was quite high, as were those in which the replacement was made with −65-mesh topaz. Bodies Nos. 2 and 3 showed a small spalling loss as compared with body No. 4, which contained flint fire clay.

TABLE IV

PROPERTIES OF MIXTURES OF TOPAZ AND CLAY

	Dry		Fired to cone 14					
	Bulk sp. gr.	Apparent porosity	Bulk sp. gr.	Apparent porosity	Total linear change (%)	Load deformation (%)	Spalling loss (%)	P.C.E.
Body 1 Topaz 80% Ball clay 20%	2.47	20.8	2.05	23.3	+0.80	0.62	15.4	37+
Body 2 Topaz 53.3% Fire clay 26.7% Ball clay 20%	2.33	21.1	2.05	21.9	−0.40	1.05	0.7	36
Body 3 Topaz 26.7% Fire clay 53.3% Ball clay 20%	2.16	21.8	2.06	20.8	−2.55	2.34	0.4	35
Body 4 Fire clay 80% Ball clay 20%	1.99	23.1	2.35	11.9	−9.65	2.75	0.3	34
Body 2-A Topaz 53.3% (−65-mesh) Fire clay 26.7% Ball clay 20%	2.19	25.5	1.96	23.4	−1.25	1.69	35.5	36
Body 3-A Topaz 26.7% (−65-mesh) Fire clay 53.3% Ball clay 20%	2.10	24.0	2.02	23.1	−3.20	3.26	30.0	35

V. Conclusions

The conclusions drawn from the preliminary investigation indicate that (1) topaz replacements improve the properties of a fire-clay refractory body; (2) high topaz replacements result in decreased spalling resistance although precalcination might improve this spalling tendency; and (3) topaz fires to a good white color, it is converted to mullite at a relatively low temperature, and it has a low thermal expansion, which suggests that it should serve the same purpose as andalusite and dumortierite in electrical porcelain, particularly in spark-plug bodies.

Acknowledgment

The authors wish to express their appreciation to A. F. Greaves-Walker and to W. W. Kriegel of the Department of Ceramic Engineering, State College Unit, University of North Carolina, for their advice and suggestions; to Paul G. Herold of the Department of Ceramic Engineering, Missouri School of Mines and Metallurgy, Rolla, Mo.; to C. R. Amberg of the New York State College of Ceramics, Alfred, N. Y., for making X-ray analyses; and to John Boyd of United Feldspar and Mineral Products Co., Spruce Pine, N. C., for making the chemical analyses.

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FACTORS AFFECTING REFLECTANCE*

By Clark Hutchison and Forrest W. Nelson

Abstract

A study was made to determine the factors that should be considered to get maximum reflectance with a given enamel. The increased reflectance obtained by fine grinding varies according to the kind of frit and opacifier used, and it was found that the proper combination of frit and opacifier is essential in developing effective reflectance. The writers conclude that the efficiency of the opacifiers varies according to the amount used; the method of blending the frits is an important factor; and the kind of clay used in the mill addition affects the degree of reflectance.

I. Introduction

A great deal of interest has been focused recently on the problem of getting equal or better coverage with white enamels at lighter application weights. The majority of discussions on this subject have dealt with fine grinding as a means of obtaining increased covering power and also with problems of workability which are a result of fine grinding.

The purpose of this paper is to show that to obtain maximum reflectance, several factors, rather than just one, should be considered. Some of these points have been discussed elsewhere,[1] but they are reviewed here to show the results of this investigation as well as to stress the importance of considering all factors that might affect reflectance.

II. Procedure

Approximately 250 enamels were prepared by varying the frit blend, opacifier, clay, and fineness of grinding† in order to determine the effect of these factors on reflectance.

The basic mill addition was frit 100 lb., clay 7 lb., opacifier (variable), $MgCO_3$ 2 oz., water 40 lb., fineness variable, and specific gravity 1.80. These enamels were applied at various weights on 4- by 6-in. panels fired at 1500°F. for $2^1/_2$ minutes, and the reflectance was determined.‡ The average reflectance curves were drawn for each enamel, and comparisons were made.

III. Data

Because it is impracticable to show curves for all of the enamels tested, the reflectance curves shown in Figs. 1 through 10 were chosen to illustrate the points emphasized in this paper.

The frits used, the variations in fineness, and the opacifier and clay are noted on the curves. Frit D had the highest initial reflectance; frits A and C were

*Presented at the Forty-Second Annual Meeting, The American Ceramic Society, Toronto, Canada, April 9, 1940 (Enamel Division). Received April 23, 1940. Revised paper received September 18, 1940.

[1] (*a*) B. T. Sweely and E. S. Prince, "Relation of Fineness of Grinding to Opacity in White Enamels," *Jour. Amer. Ceram. Soc.*, **5** [12] 855–57 (1922).
(*b*) F. R. Porter and H. H. Holscher, "Use of Finely Milled Enamel Slips," *ibid.*, **18** [2] 39–42 (1935).
(*c*) J. D. Tetrick, "Opacity Development in Cover Enamels for Sheet Steel," *ibid.*, **18** [10] 314–18 (1935).
(*d*) R. R. Danielson, "Effect of Clays on Opacity of White Enamel for Sheet Steel," *ibid.*, **19** [2] 59–61 (1936).
(*e*) G. L. Bryant and F. R. Porter, "Effect of Mill Practice and Mill Additions on Opacity of Enamels," *ibid.*, **19** [2] 55–59 (1936).
(*f*) A. I. Andrews and B. W. King, Jr., "Mechanism of Mill-Added Opacity in Porcelain Enamels," *ibid.*, **22** [6] 173–76 (1939).
(*g*) Ceramic Data Book, pp. 168–73, 11th ed. Industrial Publications, Inc., Chicago, Ill., 1938–1939.

†Fineness tests were made according to the P.E.I. Tentative Screen Test for Wet-Milled Porcelain Enamel, November, 1938.

‡Reflectance readings were made according to the P.E.I. Reflectance Test for Opaque White Porcelain Enamels, June, 1936.

somewhat lower than D, and frit B had an initial reflectance slightly under frits A and C.

IV. Discussion of Results

The curves in Fig. 1 represent two different frits, A and B; each frit had an identical mill addition and was ground to the same degree of fineness. The results indicate that increased reflectance due to fine grinding is not the same in all frits.

The increased reflectance obtained by decreasing the frit content from 8 gm. to 1 gm. on 200-mesh was practically the same for frits A and B. The change in reflectance, however, from 1 gm. on 200-mesh to 1 gm. on 300-mesh was much greater in frit B than in frit A. The total increase in reflectance of frit B by grinding to 1 gm. on 300-mesh was 4%, whereas frit A showed an increase of only $2^1/_4$ to $2^1/_2$% with the same change in fineness.

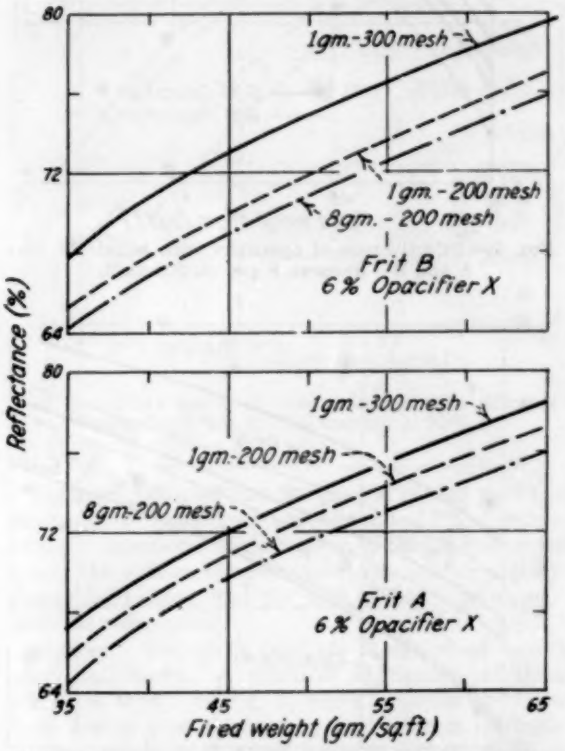

FIG. 1.—Increase in reflectance by fine grinding of frit B and frit A.

Figure 2 shows frit B with various percentages of opacifier Y, which was ground to 8 gm. on 200-mesh and to 1 gm. on 200-mesh. The results seem to indicate that the increase in reflectance obtained by grinding to 1 gm. on 200-mesh is not greatly influenced by the amount of opacifier used.

The results in Fig. 3 show that the effectiveness of the opacifiers varied according to the frit in which they were used. Opacifier Y, in this case, gave more reflectance in the frits used than opacifier X. The order of opacity between the frits, however, seems to depend on the kind of opacifier used.

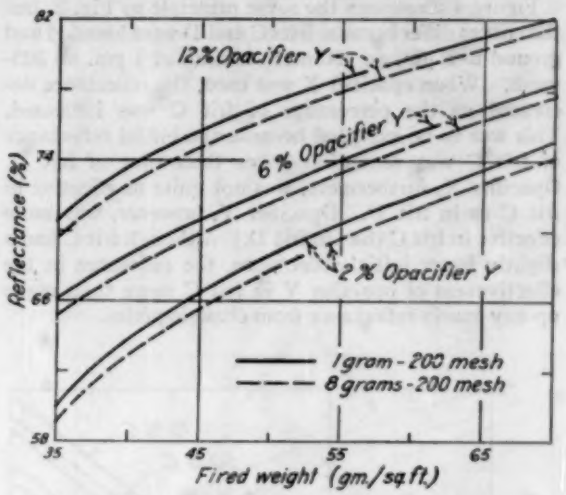

FIG. 2.—Effect of finer grinding of frit B with increasing amounts of opacifier.

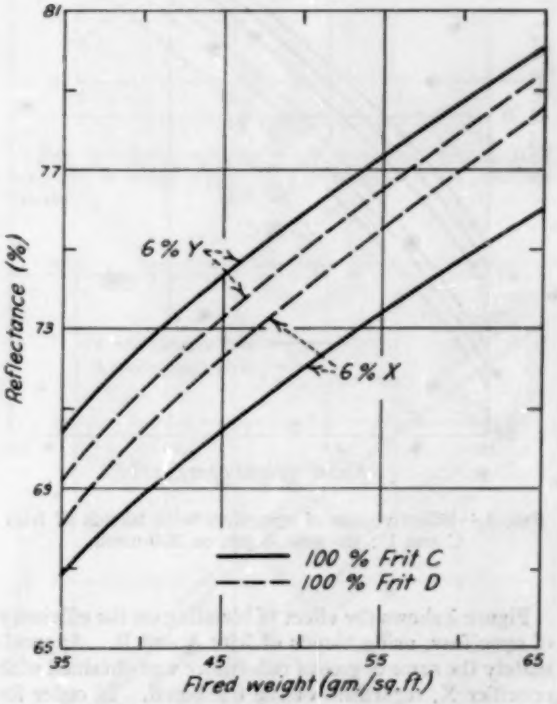

FIG. 3.—Effectiveness of opacifiers in different frits; fineness, 1 gm. on 300-mesh.

When opacifier X was used, more reflectance was obtained from frit D; the order, however, was reversed with opacifier Y even though frit C was $1^1/_2$ to 2% lower in initial reflectance than frit D. The use of opacifier Y increased reflectance $3^1/_2$ to 4% in frit C, whereas the increase with frit D was only about 1%, which indicates that opacifier Y is more effective when it is used in frit C than in frit D.

Figure 4 illustrates the same principle as Fig. 3, but the curves differ because frits C and D were blended and ground to 8 gm. on 200-mesh instead of 1 gm. on 300-mesh. When opacifier X was used, the reflectance decreased as the percentage of frit C was increased. This was to be expected because the initial reflectance of frit C was somewhat lower than that of frit D. Opacifier X, furthermore, was not quite as effective in frit C as in frit D. Opacifier Y, however, was more effective in frit C than in frit D. Although frit C had a slightly lower initial reflectance, the difference in the effectiveness of opacifier Y in frit C more than made up any loss in reflectance from changing frits.

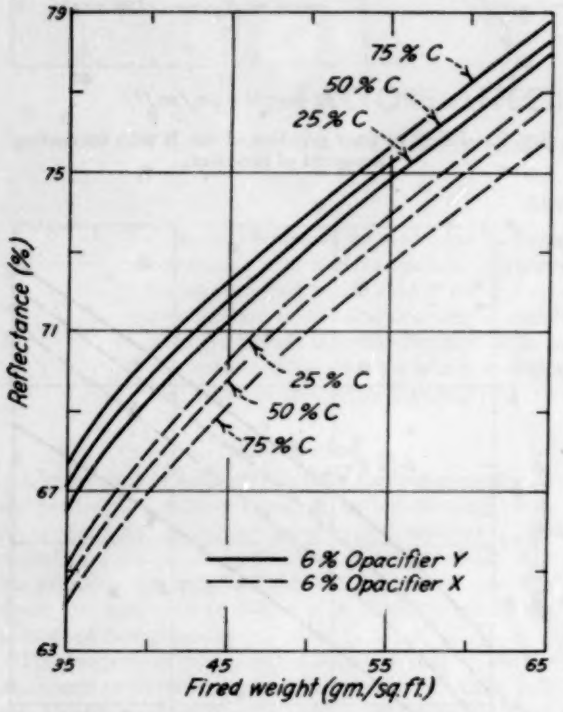

FIG. 4.—Effectiveness of opacifiers with blends of frits C and D; fineness, 8 gm. on 200-mesh.

Figure 5 shows the effect of blending on the efficiency of opacifiers, using blends of frits A and B. Approximately the same degree of reflectance was obtained with opacifier X, regardless of the frit blend. In order for this to be true, opacifier X must be more effective in frit B than A because the initial reflectance of frit B was about 1½% lower than that of frit A.

With opacifier Y, reflectance increased as the percentage of frit A was increased because frit A had a somewhat higher reflectance than frit B and opacifier Y, was more effective in frit A than in frit B.

Figure 6 shows that the benefits obtained from opacifiers vary according to the amount used; for example, at some percentages two different opacifiers may give equal results, but at other percentages one of these opacifiers may be superior.

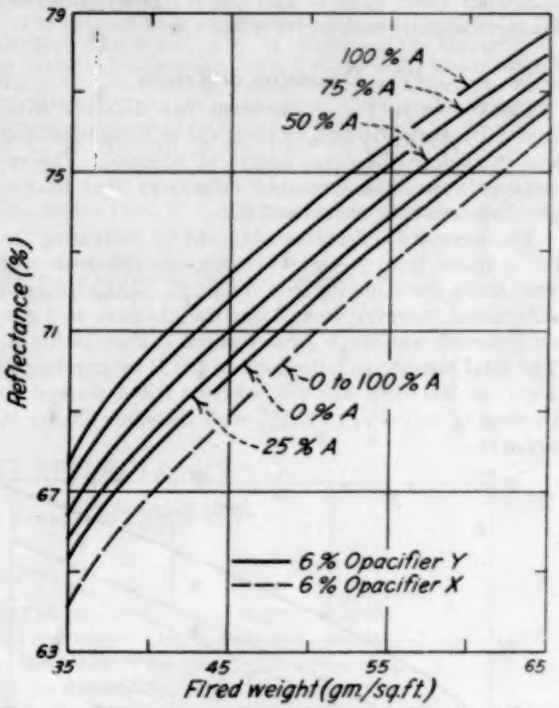

FIG. 5.—Effectiveness of opacifiers with blends of frits A and B; fineness, 8 gm. on 200-mesh.

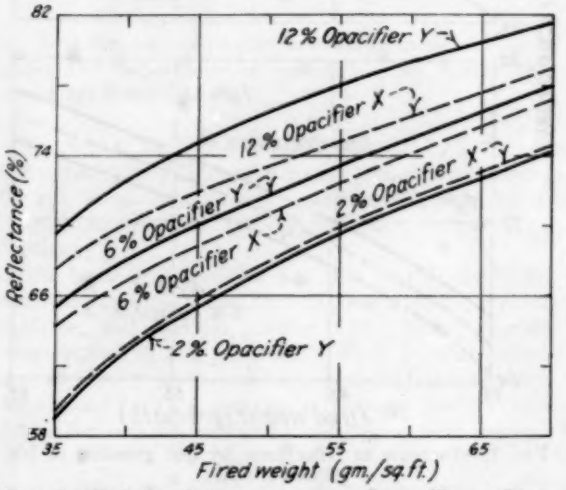

FIG. 6.—Relation between amount of opacifier and reflectance in frit B; fineness, 8 gm. on 200-mesh.

Opacifiers X and Y (Fig. 6) gave practically equal reflectance when only 2% was used, but when the amount of opacifier was increased to 6%, opacifier Y gave slightly better results. When 12% was used, opacifier Y was much superior. Raising the opacifier content from 6 to 12% gave an increase in reflectance of 4 to 4½% with opacifier Y; the same change with opacifier X resulted in an increase of only 2½%. Opacifier X apparently began to approach its saturation point at 6%.

The results in Fig. 7 indicate that increased reflectance from finer grinding is somewhat dependent on the kind of opacifier used. Opacifier Y was only slightly affected by finer grinding, but the reflectance increased with the use of opacifier X.

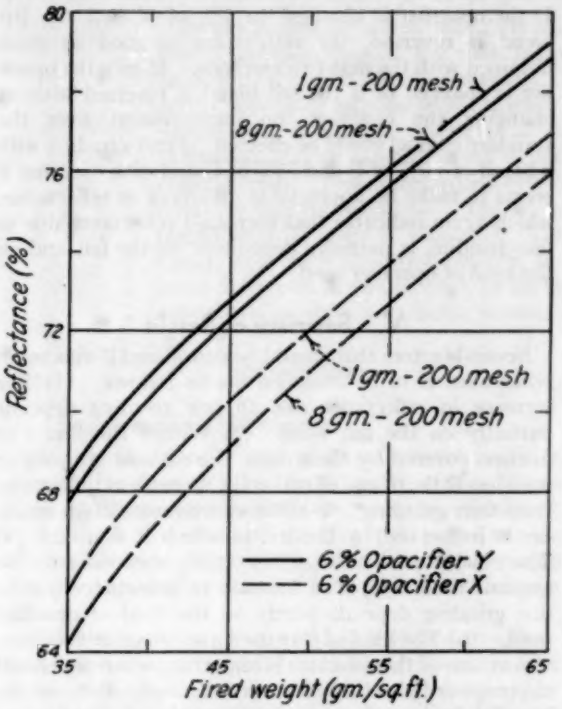

FIG. 7.—Effectiveness of finer grinding with different opacifiers; frit C 75% and frit D 25%.

Figure 8(*A*) shows that the amount of clay used had some effect on reflectance; between 6 and 7%, however, which is the amount of clay normally used in steel cover coats, the change in reflectance was not very great. Figure 8(*B*) shows that the kind of clay used also affects the reflectance.

Figures 1 through 8 illustrate how various factors affect reflectance. A practical application of these results is shown in Fig. 9, where approximately the same results were obtained by two different methods.

Assume that a standard enamel, frit B, which is ground to 8 gm. on 200-mesh (using 6% of opacifier X) is applied at 50 gm. per sq. ft. By grinding to 1 gm. on 200-mesh, the reflectance was increased 1¼%, which would allow a 6% reduction in coating. Approximately the same results could be obtained merely by changing to opacifier Y without finer grinding.

If the standard enamel is ground to 1 gm. on a 300-mesh, the reflectance would increase about 4%, which would allow a 20% reduction in coating. Practically the same results, moreover, could be obtained with no fine grinding by changing to opacifier Y and frit A. Although frit A was only 1½% higher in initial reflectance than frit B, it made a more effective frit and opacifier combination, which accounts for the improved

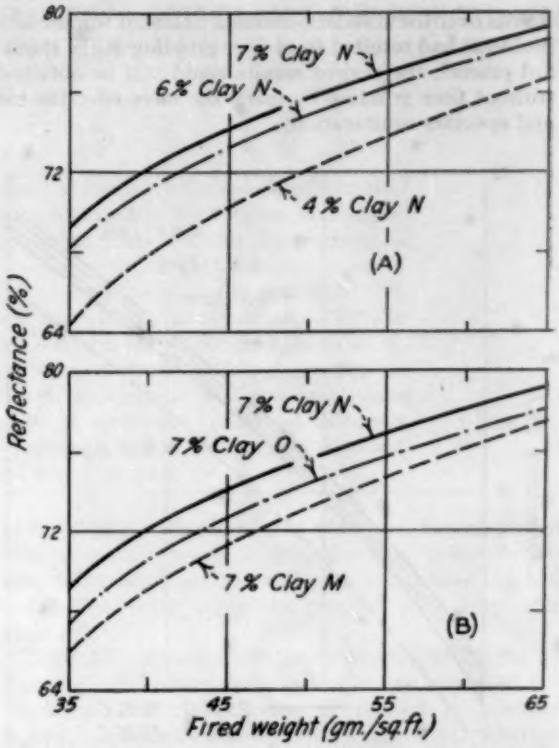

FIG. 8.—Effect of clay on reflectance; frit A 50% and frit B 50%; opacifier Y; fineness, 8 gm. on 200-mesh.

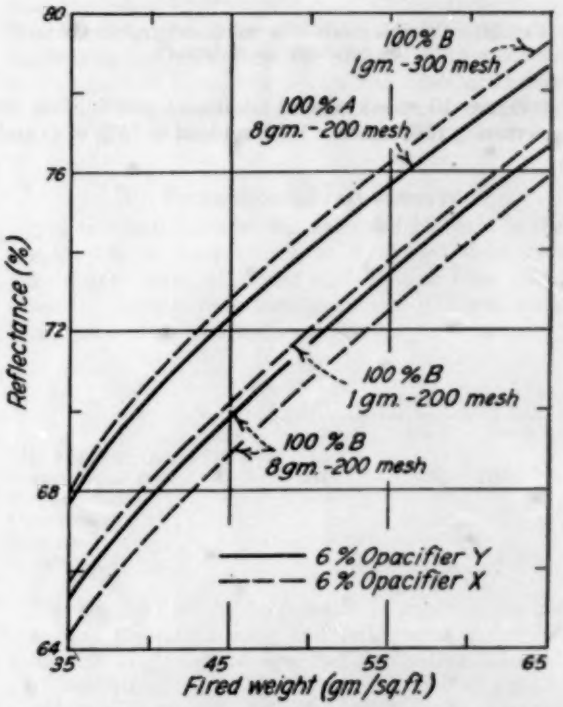

FIG. 9.—Possible increase in reflectance in frits A and B by combination of factors.

results over the standard enamel. Thus, if workability problems had resulted from finer grinding in the standard enamel, the desired results could still be obtained without finer grinding by using the more effective frit and opacifier combination.

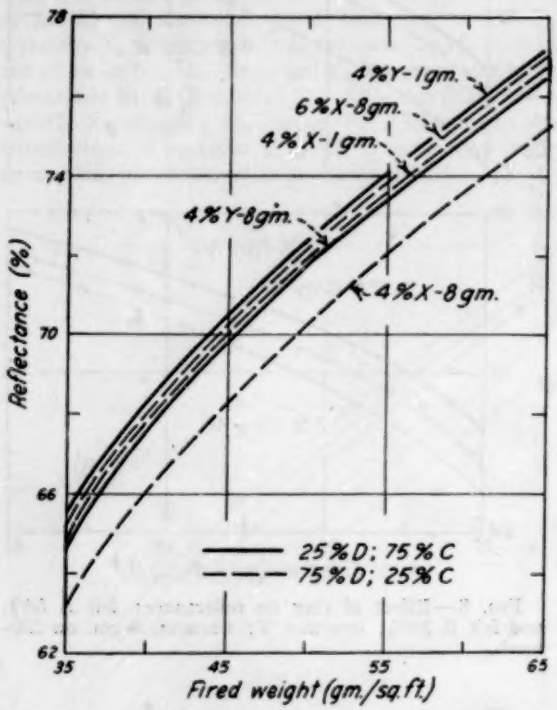

FIG. 10.—Possible increase in reflectance in frits C and D by combination of factors.

Figure 10 shows several additional possibilities for increasing reflectance. With a blend of 75% of D and 25% of C, using opacifier X, and grinding to 1 gm. on 200-mesh, reflectance was increased by 1½%, which would permit an 8% reduction in the amount of coating. The saving in weight of application is practically the same as that obtained by grinding to 8 gm. on 200-mesh and by increasing the amount of opacifier X to 6%. If the opacifier is changed to 4% of Y and the frit blend is reversed, the results are as good as those obtained with the first two methods. If only the opacifier is changed or if the frit blend is reversed without changing the opacifier, no improvement over the standard enamel would be effected. Finer grinding with a blend of 25% of D and 75% of C and with opacifier Y seems to make no appreciable difference in reflectance, which again indicates that increased reflectance due to fine grinding is partially dependent on the frit and on the kind of opacifier used.

V. Summary of Results

Several factors that should be considered if maximum reflectance is to be obtained are as follows: (1) The increase in reflectance due to fine grinding depends partially on the frit used. (2) Within the limits of fineness covered by these data, the amount of opacifier used has little, if any, effect on the increase in reflectance from finer grinding. (3) The effectiveness of an opacifier is influenced by the frit in which it is used. (4) The efficiency of an opacifier varies according to the amount used. (5) The increase in reflectance due to fine grinding depends partly on the kind of opacifier used. (6) The kind of clay used also affects reflectance.

Any one of these factors is important where increased coverage or lighter application is desired. Because the benefits from each factor are not the same in every enamel, each one should be considered and the best combination should be used to effect maximum saving.

INGRAM-RICHARDSON MFG. CO. OF INDIANA, INCORPORATED
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EFFECT OF RESIDUAL COLOR ON CONSUMER ACCEPTANCE OF PORCELAIN ENAMEL WHITES*

By John W. Iliff

Abstract

Reflectometers are widely used to give a numerical rating for the comparative whiteness of porcelain enamels, but these instruments occasionally show values in disagreement with a careful visual comparison. To find the reason for this disagreement, a survey was made to determine the effect of residual color on the consumer rating of porcelain enamel whites. A series of 12 white plaques was made ranging from 67 to 75% in reflectance, from 478 to 485 mμ in dominant wave length, and from 1.6 to 5.6% in residual color. These specifications were determined from curves run on a Hardy G. E. recording spectrophotometer. The 12 plaques were submitted to 36 persons who arranged them in order of whiteness. The order of arrangement was compared statistically, and the whites were rated in their order of acceptance. Residual color was found to have an important effect on apparent whiteness, and of these typical porcelain enamel whites, those most highly colored (blue) were preferred.

I. Introduction

(1) Specification of Whiteness

The specification of any white as viewed under a given light source calls for the definition of two factors other than apparent reflectance, namely, dominant wave length and residual color or purity.† It is no more possible to define a commercial white by giving only its degree of reflectance than it is to so define a color.

If, for example, a given white, in addition to reflectance, has a dominant wave length of 478 mμ in the blue and a residual color of 3%, the color of the white may be reproduced by mixing 3% of a pure spectral light (having a wave length of 478 mμ) with 97% of the standard illuminant used.

It is current practice to grade white enamels by reflectance readings. Although porcelain enamels are similar in color, these readings have sometimes given results contradictory to a careful visual examination. The purpose of the present investigation, therefore, was to determine the effect of color or chromaticity on the general acceptance of a white.

(2) Effect of Purity or Residual Color

In a strictly physical sense, the best whites have the highest reflectance and the lowest residual color. This, however, does not imply that whites which are judged to be the best by this standard need to be considered best by an observer. Commercial whites, moreover, with reflectances under 75% probably should be considered as grays.

MacAdam[1] investigated the apparent whiteness of cotton cloth having a dominant wave length of about 575 mμ in the yellow and a reflectance in the range of 70 to 85%. He found that whiteness, for samples of this dominant wave length, depends primarily on reflectance when the residual color is less than 3% and on residual color when the residual color is greater than 5%.

Repeated investigations have shown the danger of drawing conclusions about colors in one region of the spectrum from experiments conducted in another region. Porcelain enamel whites are blue, whereas cloth whites are yellow; what then is the effect of residual color on the acceptance of porcelain enamel whites?

Most sheet-metal enamels have an approximate dominant wave length of 480 mμ. Although the dominant wave length of some of the enamels used in this study is as high as 485 mμ, the range of 478 to 485 mμ seemed narrow enough to negate the effect of change in hue and to emphasize the effect of reflectance and the amount of color present.

II. Preparation of Test Samples

The test samples were flat enameled plates. In the preparation of these plates, 6- by 12-in. sheet-steel panels were given a ground coat of dark blue. The following enamels were then ground in 1000-gm. mills to a 5-gm. residue on a 200-mesh screen.

Table I

	Enamel		
	No. 1	No. 2	No. 3
Mill addition (basis 100 frit)			
Superopaque frit	100	100	100
Powdered clay	7	7	7
Opacifier	4	4	4
Blue oxide	0.075		
Yellow oxide			0.05

The enamel contained a commercial superopaque frit that was typical in color and reflectance, powdered Vallendar clay, and an opacifier containing calcium-antimony-titanium. The blue was a special cobalt-magnesium-stannate calcine, selected as having the lowest reflectance in the red end of the spectrum, and

* Presented at the Forty-Second Annual Meeting, The American Ceramic Society, Toronto, Canada, April 10, 1940 (Enamel Division). Received April 2, 1940. Revised copy received October 10, 1940.

† Residual color and purity are used synonymously.

[1] D. L. MacAdam: "Specification of Whiteness," *Jour. Optical Soc. Amer.*, **24** [7] 188–91 (1934).

the yellow oxide was a typical lead-antimonate yellow (Table I).

The enamel was sprayed and fired. The weight was altered to give reflectances ranging from 67 to 75% on a Hunter reflectometer (these values are about 2% lower than equivalent readings on the Hardy G. E. spectrophotometer). The maximum opacity variation allowed on any plaque was ±0.5, reflectance point readings being taken at 10 positions on each plaque. The exact spray weights used are shown on Table II.

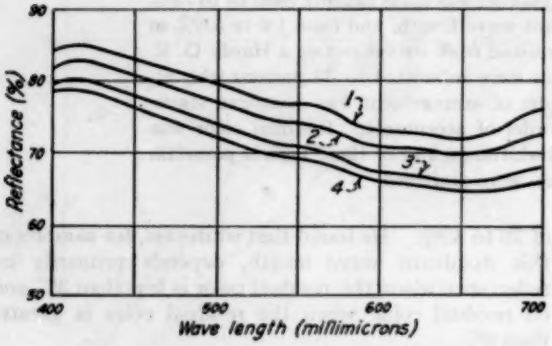

FIG. 1.—Spectral reflectance of white enamel No. 1.

III. Color Analysis of Whites

After the plaques were enameled, an average point on each plaque was selected, and the color curves for the whites were read on a Hardy G. E. recording spectrophotometer. These curves are shown in Figs. 1, 2, and 3. The tristimulus values of the white enamels were determined from these curves by using the method of ten selected ordinates[1]; these indicate the relative amounts of three primary colors which when mixed will produce a white equivalent to the sample being examined. The tristimulus values for the various

[1] A. C. Hardy, Handbook of Colorimetry, pp. 49–51, Table XIX. Technology Press, Massachusetts Inst. of Technology, Cambridge, Mass., 1936.

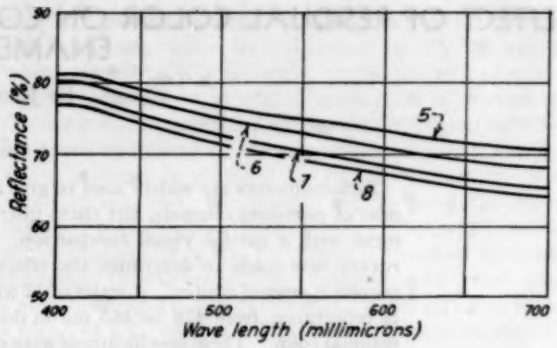

FIG. 2.—Spectral reflectance of white enamel No. 2.

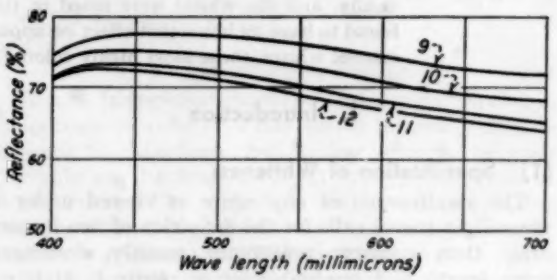

FIG. 3.—Spectral reflectance of white enamel No. 3.

spectrum colors are shown on Fig. 4; the Y value gives apparent reflectance directly as the $\bar{y}$ curve corresponds with that for visibility to a normal eye.

The tristimulus values of spectral colors are designated by the letters, $\bar{x}$, $\bar{y}$, and $\bar{z}$, whereas the corresponding tristimulus values for other colors are designated by the letters, X, Y, and Z. These symbols for tristimulus values should not be confused with those for the trichromatic coefficients, x, y, and z.

From these tristimulus values, the trichromatic coefficients of x and y were derived from the following equations:

TABLE II

Plaque No.	x	y	Y	Dominant wave length (mμ)	Residual color (%)	Weight of enamel (gr./sq. ft.)	Whiteness rating
			Enamel No. 1 (blue oxide added)				
1	0.2996	0.3068	76.3	478	4.8	57	1
2	0.2996	0.3060	73.8	478	5.0	50	2
3	0.2983	0.3051	70.5	478	5.6	44	3
4	0.2983	0.3052	69.0	478	5.6	40	4
			Enamel No. 2				
5	0.3032	0.3101	75.0	480	3.3	48	5
6	0.3019	0.3088	72.8	478	4	44	6
7	0.3015	0.3084	70.4	478	4	40	7
8	0.3016	0.3076	68.9	478	4	37	10
			Enamel No. 3 (yellow oxide added)				
9	0.3061	0.3148	75.9	485	1.6	49	8
10	0.3046	0.3132	72.6	484	2.25	44	9
11	0.3039	0.3122	70.0	483	2.7	40	11
12	0.3033	0.3116	68.9	482	3.0	37	12

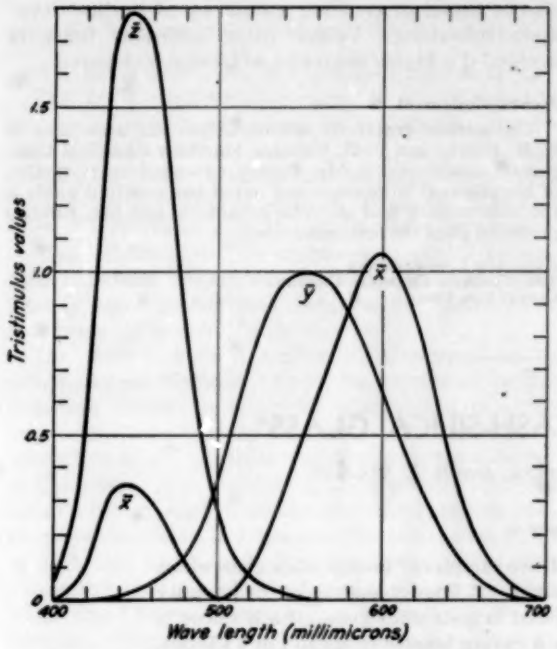

FIG. 4.—Tristimulus values for spectrum colors.

$$x = \frac{X}{X + Y + Z}$$

$$y = \frac{Y}{X + Y + Z}$$

These trichromatic coefficients were plotted on the chart, developed by the International Committee on Illumination, 1931, on which I.C.I. illuminant C (daylight) was selected as the standard illuminant. This chart shows directly the values for dominant wave length and for residual color or purity. Table II gives the essential figures derived from these calculations.

IV. Test Methods

For the visual grading of the white plaques, women rather than men were selected as observers because most of the men available were connected in some way with the manufacture of enamel or with research on the development of pigments or finishes. It might be logical to assume that although these men were trained observers, they would have a certain loss of perspective. Women, moreover, are the more important buyers of enamelware and therefore should represent a more accurate cross section of consumer opinion.

The twelve porcelain enamel samples were shown to thirty-nine women in their homes. The weather was overcast, and in all cases, daylight (and wherever possible north daylight) was used. The samples were viewed on a neutral gray background.

The procedure followed was to have the woman choose the "whitest" panel when the 12 samples were arrayed side by side. The panel selected was compared individually with every other panel and then set to one side. The same procedure was followed for each plaque until all twelve had been rated. This procedure was usually repeated two or three times.

Three of the ratings, which seemed to be absolutely inconsistent throughout, were discarded; thirty-six ratings were actually used. These ratings were compared statistically, and the results are given on Table II and plotted on Fig. 5.

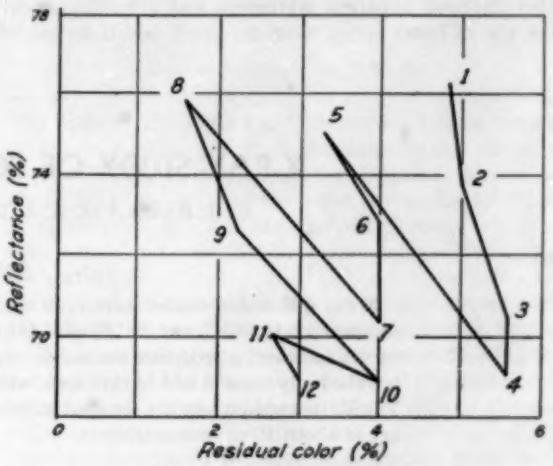

FIG. 5.—Whiteness rating.

V. Discussion of Results

The ratings, which were derived from observation under daylight illumination, were checked reasonably closely under Tungsten illumination by nine women.

Although the choice was based chiefly on the presence of color, the observers seemed to be disturbed by reflectances of less than 70%. There was a feeling of "something wrong." This was barely noticeable in the case of the bluest white panel, quite noticeable in the medium white, and very noticeable in the white with the least blue.

The laboratory men, especially those who watched their wives select the whites, were incredulous at the rating. Most of them, however, after careful review, felt selections of the women to be reasonable.

It should be emphasized that, although the twelve chosen samples include a color range typical of most commercial sheet-metal enamels as well as enamels with more blue than those now used, it does not indicate how much blue may be added to advantage. When the whites with the highest amounts of blue were compared with other whites, they did not give the impression of "blueness" but rather that of greater whiteness. There is, however, some limit or range at which an increase of blue would undoubtedly give the sensation of color.

VI. Conclusions

This survey indicates that of the enamel whites having a dominant wave length of about 480 mμ the whitest seem to be those having the highest residual

color (at least up to 5.6%). This survey, however, is not necessarily applicable to whites which have a materially different wave length, such as those found in pottery glazes.

Although this preliminary work has not been extensive enough to be used as a basis for deriving any "whiteness factor," it indicates that a final figure might show a difference in residual color approximately twice as effective as a difference in reflectance. Blue oxide additions may lower the reflectance but it may also improve apparent whiteness and actually permit the use of lower spray weights; such additions might also be useful in avoiding a build-up of "yellow tone" upon reworking. Yellow oxide additions must be avoided if a higher degree of whiteness is required.

Acknowledgment

The author gratefully acknowledges the assistance of F. H. Emery and F. C. Ellinger, Harshaw Chemical Company Laboratories. Mr. Emery extended every facility of his physical laboratory and acted as a constant guide in the determination of the color constants, and Mr. Ellinger prepared all of the test panels used.

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X-RAY STUDY OF POTASH-SILICA GLASS*

BY J. BISCOE,† M. A. A. DRUESNE, AND B. E. WARREN

ABSTRACT

X-ray diffraction studies have been made of two samples of potash-silica glass whose composition is 20.9% and 29.1% of K_2O by weight. A Fourier analysis of the intensity curves indicates a structure similar to that found in soda-silica glass. Each silicon is tetrahedrally bonded to 4 oxygen ions, with each oxygen bonded either to 1 or 2 silicons. The K^+ potassium ions are situated in holes in the silicon-oxygen network with an average of about 10 oxygen neighbors.

I. Introduction

The structure of potash-silica glass would be expected to be similar to that which has been found in the soda-silica series.[1] An X-ray diffraction study of potash-silica glass, however, has been published recently by Hartleif,[2] and it has been pointed out[3] that his experimental method caused the diffraction pattern to be influenced by an appreciable percentage of shorter wave-length radiation. The new peak at small angle which he reports is due to this short wave-length radiation. Because it is difficult to estimate the extent to which Hartleif's results and conclusions are influenced by the extraneous wave lengths, it has seemed worth while to repeat the work, using strictly monochromatic radiation.

II. Experimental

X-ray diffraction patterns were made of two samples of potash-silica glass, the compositions being 20.9% and 29.1% of K_2O by weight.‡ The experimental technique and treatment of the data were the same as that used for the soda-silica series.[1] The samples from which diffraction patterns were obtained were in the form of rods, 0.36 mm. in diameter. With samples of this size, corrections for X-ray absorption amounted to less than 2%. The patterns were made in an evacuated camera with a radius of 4.40 cm., using $MoK\alpha$ radiation (λ = 0.710 A) monochromated by reflection from a rock-salt crystal. Patterns of vitreous silica and of the 29.1% K_2O glass were also made, using $CuK\alpha$ (λ = 1.539 A) which had been similarly monochromated by crystal reflection. The samples in this case were flat slabs and of optimum thickness for the wave length, λ = 1.539 A. There was no trace of the small-angle peaks reported by Hartleif.

The intensity curves were obtained from the microphotometer traces of the diffraction patterns, and the corrections for polarization were made in the usual way. The final curves are shown in Fig. 1, the vitreous silica curve being included for comparison. From a Fourier analysis of the intensity curves of Fig. 1, the corresponding radial-distribution curves of Fig. 2 are obtained.

III. Results

The intensity curves of Fig. 1 show a striking resemblance to one another. There is a gradual transition, however, from pure silica to the glass with the highest potash content. The first main peak, which in

* Presented at the Forty-Second Annual Meeting, The American Ceramic Society, Toronto, Canada, April 10, 1940 (Glass Division). Received June 13, 1940.

This paper constitutes the fifth report of work done with the assistance of the Glass Research Fellowship sponsored by seven American glass manufacturers.

† Glass Research Fellow.

[1] B. E. Warren and J. Biscoe, "Fourier Analysis of X-Ray Patterns of Soda-Silica Glass," *Jour. Amer. Ceram. Soc.*, **21** [7] 259–65 (1938).

[2] G. Hartleif, "Struktur des Kieselglasses und der Kalisilikatgläser," *Z. anorg. allgem. Chem.*, **238** [4] 353–84 (1938); *Ceram. Abs.*, **19** [1] 10 (1940).

[3] J. Biscoe, C. S. Robinson, and B. E. Warren, "X-Ray Study of Boric Oxide-Silica Glass," *Jour. Amer. Ceram. Soc.*, **22** [6] 180–84 (1939); see note, p. 181.

‡ The authors are indebted to A. N. Finn of the National Bureau of Standards who kindly furnished the samples and their analyses.

pure silica comes at $\frac{\sin\theta}{\lambda} = 0.12$, shifts over to 0.144 and 0.155 for 20.9% and 29.1% of K_2O, respectively.

The radial-distribution curves of Fig. 2 give the number of neighboring atoms to be found at any distance from the various atoms. Each curve is a superposition of those curves giving the number of neighbors about each kind of atom in the glass. The positions of the peaks give the interatomic distances directly. If, therefore, the distances to expect between different atoms are known, the peaks can be identified. The expected interatomic distances are indicated by short vertical bars in Fig. 2.

The peak at 1.62 A evidently corresponds to the silicon-oxygen distance. From the results of crystal-structure studies, it is known that silicon is always surrounded tetrahedrally by 4 oxygens at a distance of about 1.62 A, and the same would be expected to be true in the glass. A calculation of the number of oxygens about a silicon, made from the area under the first peak, gives the numbers 4.3, 4.4, and 4.7 for pure silica, 20.9% of K_2O, and 29.1% of K_2O, respectively. That these values run high is probably due to the approximations which must be made in carrying through the Fourier analysis. In particular, the approximation that the atomic scattering factors can be set proportional to one another becomes worse the greater the difference in atomic numbers. If the number of oxygens bonded to a silicon were actually greater than four, the silicon-oxygen distance would be expected to be greater than 1.62 A, as an increase in interatomic distance always accompanies an increase in the coordination number. In the Fourier analysis, peak positions are more accurate than peak areas, and the peak position, 1.62 A, may be concluded to indicate that each silicon is bonded tetrahedrally to 4 oxygen neighbors in the potash-silica glasses.

From the geometry of the tetrahedron, the distance between 2 oxygens in the same tetrahedral group is given by

$$O\text{–}O = 1.62\sqrt{\frac{8}{3}} = 2.65 \text{ A.}$$

The sum of the ionic radii, determined from crystal structure studies, gives a potassium-oxygen distance, K–O = 2.7 A. The peak on the distribution curve at about 2.6 to 2.7 A is therefore the two peaks, O–O and K–O, unresolved. The next definite distance is that of silicon to silicon, and this distance is represented by the peak at 3.2 A.

On the basis that there are 4 oxygens about each silicon and that each oxygen, where possible, is shared by 2 silicons and otherwise by 1 silicon and knowing the composition of the glass, the number of oxygens about an oxygen at 2.65 A and the number of silicons about a silicon at 3.2 A may be calculated. The areas of the corresponding peaks can also be computed from these figures. If this is done and if the sum of the two areas is subtracted from the area under the distribution curve, the remaining area is found to correspond to about 10 oxygens about each potassium atom. This value corresponds well to what would be expected from a consideration of atomic sizes. In the soda-silica series,[1] about 6 oxygens were found to be the

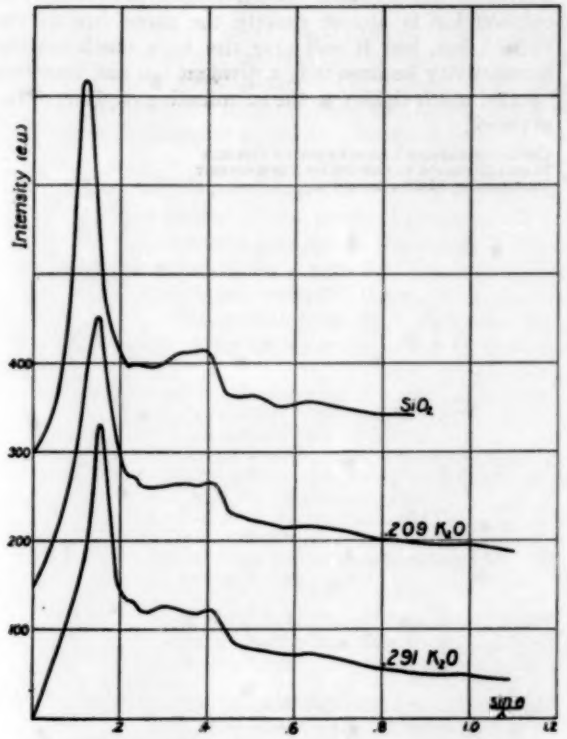

FIG. 1.—Experimental X-ray intensity curves for samples of potash-silica glass.

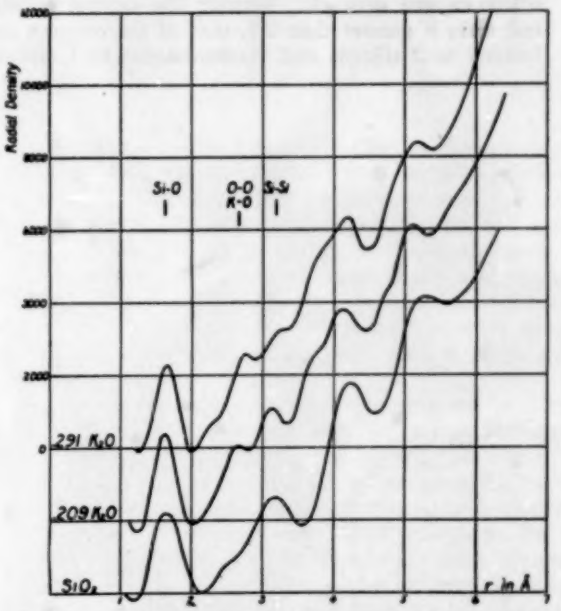

FIG. 2.—Radial distribution curves for samples of potash-silica glass.

average number surrounding a sodium ion. The potassium ion, owing to its larger size, can contact more oxygen neighbors than the sodium ion.

IV. Discussion

The X-ray results and the physical properties indicate the same type of structure for potash-silica glass as

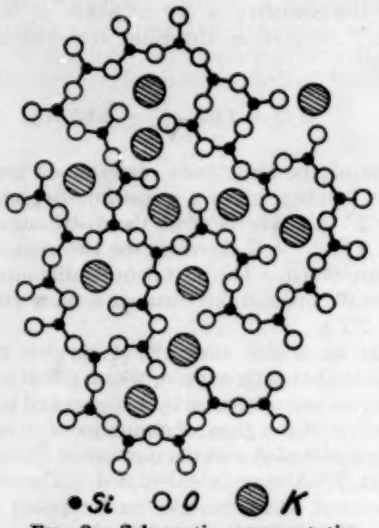

FIG. 3.—Schematic representation in two dimensions of the structure of potash-silica glass.

that found in the soda-silica series. Each silicon is bonded tetrahedrally to 4 oxygens at a distance of about 1.62 A. The oxygen introduced by the potash as well as that from the silica takes part in forming a silicon-oxygen network. Because the oxygen to silicon ratio is greater than 2.0, part of the oxygens are bonded to 2 silicons and the remainder to 1 silicon. The potassium ions, K^+, situated in the holes in the silicon-oxygen network, average about 10 oxygen neighbors. The structure is represented schematically in Fig. 3, and, as the representation is in two dimensions, each silicon is shown to be bonded to 3 oxygens only rather than to 4.

The variation of physical properties with temperature and alkali content would be explained in the same way as for the soda-silica series.[1] In comparing potash-silica with soda-silica glass, there are two differences which work in opposite directions. Owing to the larger size of the K^+ ion, the K–O distance is greater than the Na–O distance, and the force of attraction between the alkali ion and the surrounding oxygens consequently is less for the potash-silica series. On the other hand, there are more oxygen neighbors bonded to the K^+ ion. The potassium ion therefore is held to the remainder of the structure by weaker bonds but by more of them, and it is difficult to say whether there is a net increase or decrease in the tightness with which the atom is held.

For the process of electrical conductivity, the larger size of the potassium ion should make migration through the holes in the silicon-oxygen network more difficult than for the sodium ion. For the three ions, Na^+, K^+, and Ca^{++}, the sodium ion should give rise to the highest conductivity. Being monovalent, it is loosely held, and because it is not a large ion there is room to migrate through the network holes. The potassium ion would be expected to give rise to a smaller conductivity owing to its larger size and greater difficulty in migrating through the silicon-oxygen network. The calcium ion is almost exactly the same size as the sodium ion, but it will give rise to a much smaller conductivity because it is a divalent ion and therefore bonded much tighter to the surrounding oxygens of the network.

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ELASTIC AND VISCOUS PROPERTIES OF SEVERAL POTASH-SILICA GLASSES IN THE ANNEALING RANGE OF TEMPERATURE*

By Nelson W. Taylor and Robert F. Doran

Abstract

Quantitative data are presented, and conclusions are drawn regarding the molecular nature of elastic and viscous processes in certain silicate glasses.

I. Introduction

During the past few years, this laboratory has conducted a systematic series[1] of investigations on the elastic and viscous properties of several glasses of relatively simple chemical composition with the object of seeking a molecular interpretation of these phenomena, particularly in the annealing range of temperature.

The annealing range is of special interest inasmuch as the behavior of glass in this range may be markedly modified by suitable heat treatment.

The paper on soda-silica glasses[1(c)] showed that, whereas the viscosity steadily increases at constant temperature as the percentage of silica increases, the temperature coefficient of viscosity is independent of composition. This means that the energy required to permit viscous shear in these glasses bears no relation to the fraction of silica or soda but depends only on the nature of the weakest atomic bonds in the glass, which presumably are the electrostatic bonds joining sodium and oxygen ions, the Na-O bonds. The effect of substituting the larger potassium ion, K^+, for the sodium ion, Na^+, has therefore been studied to see how this substitution would affect the viscosities, the elasticities, and their respective temperature coefficients in several simple potash-silica glasses. The results, which have proved to be interesting not only in a quantitative but also in a qualitative sense, are presented here.

II. Materials and Experimental Procedures

The compositions of the glasses,† listed in Table I, represent the chemical analyses of the samples used.

The percentages of R_2O_3 were 0.4, 0.6, 0.6, 0.5, and 0.5 and ignition losses were 0.1, 0.3, 0.5, 0.1, and 0.1, respectively. The potash-lime-silica glass was introduced into the series to learn the effect of lime, and the soda-lime glass was tried in order to have a comparison with a glass of substantially the same lime content and the same alkali to silica ratio. Another glass with approximately 50% of K_2O was prepared, but this glass deliquesced too easily for satisfactory and reliable measurements and was eliminated from the series. Fibers, approximately 25 cm. long and 0.07 cm. ±0.002 cm. in diameter, were drawn, and after careful inspection to select only those free of cords and seeds, they were stored over anhydrous magnesium perchlorate in glass tubes until they were ready for the high-temperature tests.

The furnace and experimental procedure for the measurements of fiber elongation were the same as those used in the work on the soda-silica glasses.[1(b)] The furnace temperature showed a uniformity of 0.25°C. along the length of the glass fiber, and the absolute accuracy was approximately 0.40°C. Changes in fiber length, owing to elastic or viscous processes, were measured to an accuracy of 0.0002 cm.

Table I

Analyses of Glasses

Glass No.	K_2O (wt. %)	SiO_2 (wt. %)	CaO (wt. %)	Na_2O (wt. %)	Mol ratio O/Si
1	24.4	74.8			2.21
2	33.2	66.0			2.32
3	41.3	58.0			2.44
5	28.5	63.0	8.3		2.43
6		69.5	9.0	2.09	2.43

All measurements of fiber elongation were made after the glass had been completely stabilized, that is, after it had been held at the test temperature until the rate of elongation, resulting from the small fixed load, was linear. This rate changes as long as the glass is undergoing internal molecular rearrangements and strain release. The reproducibility of the experimental data indicates that duplicate samples were brought to a condition of molecular equilibrium, that is, stabilized before each run.

In a typical curve, depicting the progress of flow (Fig. 1), the fiber was first heat treated at the test temperature until a constant rate of flow, *AB*, was attained. Upon application of an additional load to this stabilized fiber, an instantaneous (or very rapid) elastic elongation, *BC*, occurred. The rate of elongation then gradually slowed down to constant values shown by section *CDE*. This changing rate is due to a combination of a delayed elastic process and a viscous flow, the rate of the latter part being given by the slope, *KDE*. When the additional load was removed,

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* Presented at the Forty-First Annual Meeting, The American Ceramic Society, Chicago, Ill., April 18, 1939 (Glass Division). Received July 18, 1940.

Submitted in partial fulfillment of the requirements for the degree of Master of Science, The Pennsylvania State College, State College, Pa., February, 1939.

[1] (*a*) N. W. Taylor, E. P. McNamara, and Jack Sherman, "Elastico-Viscous Properties of a Soda-Lime-Silica Glass at Temperatures near the 'Transformation Point,'" *Jour. Soc. Glass Tech.*, **21** [83] 61–81 (1937); *Ceram. Abs.*, **17** [8] 273 (1938).

(*b*) N. W. Taylor and P. S. Dear, "Elastic and Viscous Properties of Several Soda-Silica Glasses in Annealing Range of Temperature," *Jour. Amer. Ceram. Soc.*, **20** [9] 296–304 (1937).

(*c*) N. W. Taylor, "Law of Annealing of Glass: Quantitative Treatment and Molecular Interpretation," *ibid.*, **21** [3] 85–89 (1938).

† Supplied through the courtesy of W. C. Taylor, Corning Glass Works, Corning, N. Y.

an instantaneous elastic contraction, *EF*, occurred, equal in amount to *BC*. This was followed by a period, *FG*, during which the delayed elastic contraction opposed the viscous flow. The curve, *FGH*, shows that the rate of elongation fell to zero and then increased to the constant rate, indicated by the slope, *LGH*, which is parallel to and therefore equal in magnitude to the slope, *AB*. The elastic effects appear to be completely reversible. Because the entire elongation during a run is only a small percentage of the original fiber length, changes in diameter are negligible.

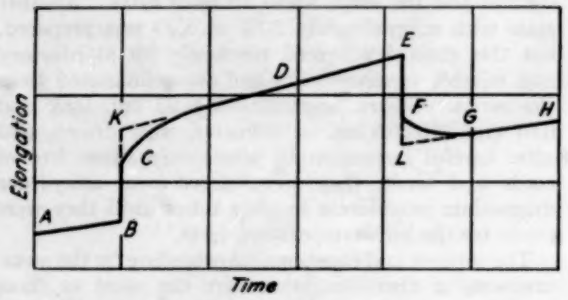

FIG. 1.—Typical flow curve.

III. Experimental Results

(1) Viscosities

The viscosity, η, of a cylindrical rod or fiber of length, L, and diameter, D, which is elongating at a rate, k_v, under tensional load, Mg, is given by the equation,

$$\eta = 80MgL/(\pi D^2 k_v). \qquad (1)$$

The rate, k_v, of course, must be taken from a linear section of the elongation-time curve, that is, after the delayed elastic process is completed. The viscosities of glasses are given at a number of temperatures which have been computed by means of equation (1) from actual runs made at these temperatures.

A plot of the logarithm of the viscosity versus the reciprocal of the absolute temperature, that is, $\log \eta$ vs. $1000/T°$ is shown in Fig. 2. The data fall satisfactorily on straight lines which conform to the relation, $\log \eta = A/T + B$. The slope of each of these straight lines, A, is a measure of the "activation energy" required to permit viscous flow by breaking certain ionic bonds. It is interesting to compare this quantity with the corresponding term for some glasses previously studied. Before doing this, however, it should be noted that, at constant temperature, the viscosities of glasses Nos. 1, 2, and 3 decrease in that order, which is the order of decreasing silica content; the potash-lime-silica glass, No. 5, has a higher viscosity than No. 6, the corresponding soda-lime-silica glass, although glass No. 6 has a higher temperature coefficient of viscosity. The differences between these two glasses will become still greater as the temperature rises unless the slopes change materially.

Table III gives the slopes, A, of the several lines which conform to the relation $\log \eta = A/T + B$. Corresponding data for other glasses have been taken from the literature. The actual "activation energy" may be computed by multiplying the A values by the quantity, $2.303R$ (= 4.578), wherein R is the "gas constant" in calories per mol, and 2.303 is the conversion factor from common to natural logarithms.

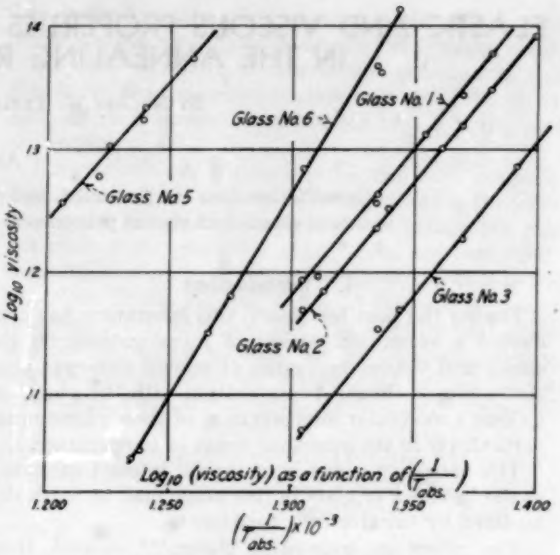

FIG. 2.—Effect of temperature on viscosity.

TABLE II

VISCOSITIES OF STABILIZED GLASSES

Glass No.	Temp. (°C.)	Viscosity (poises)	1000/T°
1	450.2	5.58×10^{13}	1.382
	457.8	2.82 " "	1.370
	461.8	1.70×10^{13}	1.362
	476.0	3.62 " "	1.335
	476.0	4.31 " "	1.335
	489.5	9.86×10^{11}	1.311
	494.0	8.70 " "	1.304
2	441.0	8.14×10^{13}	1.400
	451.0	3.01 " "	1.382
	457.8	1.53 " "	1.370
	461.5	1.03 " "	1.362
	474.2	3.32×10^{12}	1.338
	476.0	2.40 " "	1.335
	488.6	7.58×10^{11}	1.313
	494.0	5.13 " "	1.304
3	429.0	4.36×10^{13}	1.425
	445.8	7.36×10^{12}	1.392
	457.8	1.91 " "	1.370
	471.0	5.12×10^{11}	1.344
	476.0	3.63 " "	1.335
	494.0	5.32×10^{10}	1.304
5	522.0	5.76×10^{13}	1.259
	533.5	2.26 " "	1.240
	533.8	1.69 " "	1.239
	543.0	1.05 " "	1.225
	545.8	6.09×10^{12}	1.221
	557.0	3.72 " "	1.206
6	471.0	1.45×10^{14}	1.344
	475.0	4.35×10^{13}	1.337
	476.0	4.60 " "	1.335
	494.0	7.07×10^{12}	1.304
	511.0	6.87×10^{11}	1.276
	516.4	3.25 " "	1.266
	534.5	3.80×10^{10}	1.238
	536.0	3.14 " "	1.236

TABLE III

TEMPERATURE COEFFICIENTS OF VISCOSITY, AND "ACTIVATION ENERGIES" FOR VISCOUS FLOW IN SEVERAL SIMPLE GLASSES

Glass	Range of log η	No.	Slope A	Activation energy
Vitreous silica*	10–12		41,700	191,000
Soda-lime-silica†	12–15		37,000	169,000
" " " ‡	"		33,600	154,000
" " " §	10–14	6	33,900	155,000
Soda-silica ‖	11–15	1	33,400	153,000
" "	"	SS	31,500	144,000
" "	"	2	32,600	149,000
" "	"	X	33,800	155,000
" "	"	SSC	33,900	155,000
Potash-lime-silica§	11–13	5	22,400	103,000
Potash-silica§	10–14	1	23,200	106,000
" "	"	2	23,000	105,000
" "	"	3	24,000	110,000

* M. P. Volarovich and A. A. Leontieva, "Viscosity of Quartz Glass Within Softening Range," *Jour. Soc. Glass Tech.*, **20** [79] 139–43 (1936); *Ceram. Abs.*, **16** [1] 11 (1937).

† H. R. Lillie, "Viscosity of Glass Between Strain Point and Melting Temperature," *Jour. Amer. Ceram. Soc.*, **14** [7] 502–11 (1931).

‡ N. W. Taylor, E. P. McNamara, and J. Sherman, p. 75 of footnote 1(*a*).

§ Present investigation.

‖ N. W. Taylor and P. S. Dear, p. 301 of footnote 1(*b*).

Table III brings out several interesting points. The first is that the activation energies permitting viscous flow are substantially the same for the three potash-silica glasses and are therefore probably independent of the percentage composition within this range. The energy probably is that required to break the weakest ionic bonds in these glasses, which in this case will be the potassium-oxygen bonds, K^+-$O^=$. This energy is definitely much smaller (approximately two thirds of that value) than that in the soda-silica series. This result is qualitatively in harmony with the fact that the potassium ion is a much larger ion than sodium, the ionic radii being 1.33 and 0.98 A, respectively. This larger size means greater separation (center-to-center) for the K^+-$O^=$ bond as compared with the Na^+-$O^=$ bond; it therefore has weaker electrostatic attraction and less energy is required to break the K^+-$O^=$ bond. The larger sized K^+ ion also takes 10 oxygen-ion neighbors, a greater coordination number than the Na^+ ion of 6. Warren and his co-workers[2] have shown this by an examination of the X-ray diffraction patterns of the corresponding glasses.

This means that, in the sense of Pauling,[3] the "electrostatic bond strength" will be reduced. All of these facts are consistent with the lower activation energy required to bring about viscous flow in the potash-silica glasses. From the standpoint of the practical glass man, the potash-silica glasses are "sweeter," that is, they are easier to handle because their viscosity is not so sensitive to changes of temperature as in the soda-silica series.

Table III also shows that the energy term for potash-silica glasses remains practically unchanged when lime is added. This may be explained only if the calcium-oxygen bonds, Ca^{++}-$O^=$, remain firm and unbroken during the viscous flow process. In other words, at these temperatures and in this viscosity range, only the weakest bonds, K^+-$O^=$, are broken to permit shear and viscous flow. The same conclusion (that the Ca^{++}-$O^=$ bonds remain firm and unbroken) is to be drawn from the practical equality of the activation energies of the soda-lime glass with the soda-silica glasses. This result is not surprising because the doubly charged calcium ion would be expected to attach itself about twice as firmly to the oxygen ion as would the singly charged potassium or sodium ion. As long as only one type of bond is being broken, the log η vs. $1/T$ plot probably will be linear. As soon as the temperature gets high enough to supply sufficient energy to break other stronger bonds, the log η vs. $1/T$ plot will change its slope. A complete interpretation of the viscosity curve over a wide temperature range would require a knowledge of all of the bond strengths concerned.[4]

A third point to be noted in Table III is that the activation energy as determined in the present study on a soda-lime-silica glass* is almost exactly the same as that found several years ago on another soda-lime-silica glass,† although the percentage composition of the other glass was quite different. Both values are somewhat lower than that obtained by Lillie[5] on a glass in this series; this is not surprising because the importance of first stabilizing the glass at the test temperature was not fully realized at that time.

The role of the oxygen to silicon ratio in affecting the structure of glass has been discussed in earlier publications. The silicate part of the structure in silicate crystals may be a 3-dimensional network, SiO_2; a sheet as in the mica group $(Si_2O_5)^{2-}$; a chain as in the amphiboles $(Si_4O_{11})^{6-}$ or in the pyroxenes $(SiO_3)^{2-}$; or a separate tetrahedron as in the olivines $(SiO_4)^{4-}$. The extensive 3-dimensional network would account for the high viscosity of vitreous silica, whereas the small independently acting SiO_4 groups in basic melts, such as fused olivines, would be expected to yield low viscosity, as in fact such melts do. To compare the viscosities of soda-silica and potash-silica glasses, pairs of glasses with the same oxygen to silicon ratio should be examined because this factor has so much influence on viscosity. Table IV shows such a comparison.

Three pairs of glasses having essentially the same molecular ratio, O to Si, are grouped in Table IV. In each case, a temperature exists at which the two glasses of each pair have the same viscosity. Above and below this temperature, the viscosities would be unequal because the soda-silica glass always has the higher temperature coefficient (as shown earlier in this paper). When lime is introduced into a soda-silica or

[2] J. Biscoe, M. A. Druesne, and B. E. Warren, "X-ray Study of Potash-Silica Glasses." See this issue of *The Journal*, pp. 100-102.

[3] Linus Pauling, "Principles Determining Structure of Complex Ionic Crystals," *Jour. Amer. Chem. Soc.*, **51**, 1010–26 (1929).

[4] Cf. N. W. Taylor, "Viscosity and Electrical Resistivity and Their Bearing on Nature of Glass," *Jour. Amer. Ceram. Soc.*, **22** [1] 1–8 (1939).

* See § footnote, Table III.

† See ‡ footnote, Table III.

[5] H. R. Lillie, see † footnote, Table III.

a potash-silica glass to give an O to Si ratio of 2.43 (glasses Nos. 6 and 5), the viscosities of these glasses are affected to different degrees, that of the potash glass being increased much more than that of the soda glass. Based on an extrapolation of the existing data, glasses Nos. 6 and 5 would each have an approximate viscosity of 10^{17} poises at about 425°C., but at higher temperatures the potash-lime glass would have the higher viscosity because that of the soda-lime glass falls off much more rapidly with rise of temperature (Fig. 2).

TABLE IV

COMPARISON OF CERTAIN SODA AND POTASH SILICATE GLASSES

Glass (%)	Mol ratio O/Si	Temp. (°C.)	Viscosity	Temp. coefficient
Na_2O 33.02	2.44	453	3.2×10^{13}	High
K_2O 41.3	2.44	453	3.2×10^{13}	Low
Na_2O 23.46	2.30	459	1.3×10^{13}	High
K_2O 33.2	2.32	459	1.3×10^{13}	Low
Na_2O 19.84	2.24	476	4.5×10^{13}	High
K_2O 24.4	2.21	476	4.5×10^{13}	Low

(2) Elastic Properties

The elastic elongation of a glass fiber under load is made up of an instantaneous (or rapid) part, I, and a delayed or more slowly acting part, which in the case of the soda-lime silica glass[1(a)] and of the soda-silica glasses,[1(b)] was found to obey the simple Maxwell relation, that is, $-dl/dt = kl$. The rate constants, k, for the delayed elastic process were systematically dependent on the temperature. Integration of the Maxwell relation leads to the expression, $\ln l/l_0 = -kt$, wherein l_0 is total delayed elastic elongation, and l, the unstretched length at any time, t. The procedure for evaluating l_0 and l has been described in the other papers.

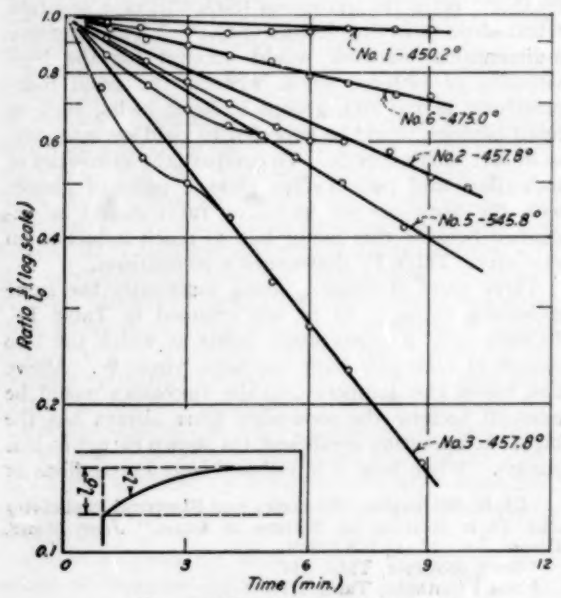

FIG. 3.—Log l/l_0 versus time.

When the elongation curves for potash-silica glasses are treated in this way, a new effect is observed. The data for the early part of the delayed elastic elongation fall below the best straight line which represents the plot of log l/l_0 vs. t. This negative departure of the log l/l_0 values is clearly depicted in Fig. 3. One rate constant, k, probably does not describe the whole course of the delayed elastic process, but two or more "unimolecular" processes apparently are operating with different characteristic rates and the observed phenomena represent the summation of these processes

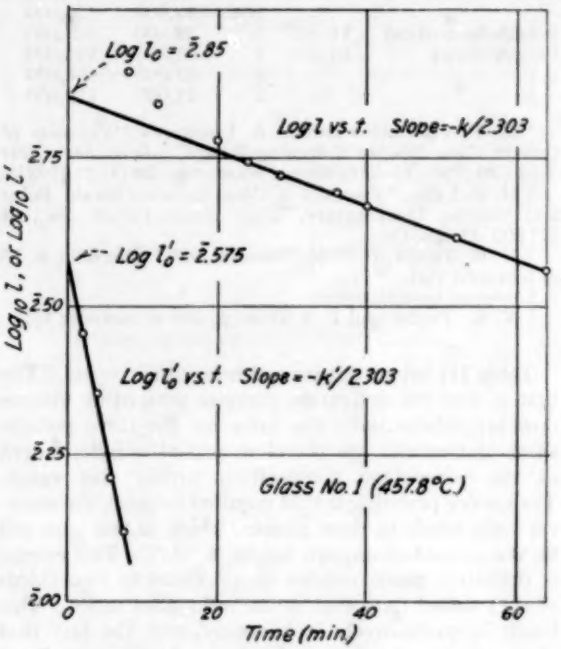

FIG. 4.—Evaluation of constants for fast and slow elastic processes.

operating simultaneously. If the first process is distinctly more rapid than the second, the characteristic rate constants may be evaluated by examining the early and late data independently. This was done in the following manner. From the original curves of elongation vs. time, a list of values of the unstretched length, l, for various times, t, was prepared; a plot was made of log l vs. t, and an extrapolation was made back to the zero time (when the additional load was added to the fiber). The early points were neglected in making this extrapolation to get log l_0, and weight was given to those later points which were self-consistent in falling on a straight line (Fig. 4). Values of log l, corresponding to the early part or possibly the first quarter or first third of the duration of the delayed elastic process, may be read from the plot. These calculated l values are less than those actually observed for the early time period. The differences then are plotted in the form, log l' vs. t, and they fall satisfactorily on a straight line whose slope is considerably greater than that of the first plot, thus indicating a molecular process which goes much more rapidly than the other. This procedure is ex-

actly like that used by Taylor in analyzing the data on the birefringence of glass.[1(e)] The entire delayed elastic elongation at any time, t, would thus consist of two terms, $l_0(1-e^{-kt})$ and $l_0'(1-e^{-k't})$, instead of only the first term. More such terms could be added if needed. This means, in a qualitative sense, that the glass probably contains molecular groups of various sizes. The application of an additional load to a fiber is considered to bring about an elastic elongation by turning or orienting these molecular groups so that the longest axis of each tends to become parallel to the fiber direction. The smallest groups will respond quickly to the added load and will give a large rate constant in the equation, $-dl/dt = k'l$, or in the corresponding expression, $l_0'(1-e^{-k't})$; larger groups will respond more slowly and will give different values for k and l_0. Although this complexity was evident in potash-silica glasses, a re-examination of the data on soda-silica glasses shows that it is also present but to such a small degree that it has been overlooked. The soda-silica glasses apparently are more homogeneous in their molecule types, at least in the annealing range of temperature.

Table V presents a few numerical constants for the fast as well as the slow delayed elastic elongation processes. The prime superscripts (′) refer to the faster process.

TABLE V

CONSTANTS FOR DELAYED ELASTIC PROCESS IN POTASH-SILICA AND POTASH-LIME-SILICA GLASSES

Glass	Temp. (°C.)	l_0	k	l_0'	k'
1	457.8	0.071	0.010	0.036	0.132
2	461.5	0.079	0.058	0.082	0.316
5	516.0	0.021	0.128	0.017	0.498

The rate constants listed in Table V are also shown in Fig. 5, wherein $\log l/l_0$ vs. t is plotted. For each run of a certain glass at a given temperature, three lines are drawn corresponding to the rate constants, k, k', and k_m. The constant, k_m, might be called the "mean" rate constant, and it is simply the ordinary rate constant such as that determined in the published studies of soda-silica and soda-lime-silica glasses. The failure of this single constant to represent properly the actual trend of the observed data for $\log l/l_0$ gave rise to the more elaborate mathematical and theoretical analysis of the delayed elasticity. Note in Fig. 5 that the earlier points fall nicely on the k' line, whereas the later points are satisfied by the k line with its smaller numerical value. Figures 4 and 5 are strong evidence that the orientation phenomena which are involved in elastic displacements require the action of at least two kinds (or sizes) of molecular groups. If the experimental data were of sufficient precision, a treatment using three rate constants for three simultaneous orientation processes would probably be necessary. In fact, even the instantaneous (or very rapid) elastic elongation should be represented, not by I, but rather by $I(1-e^{-k''t})$; this reduces to I when k'' is large, which for practical purposes is the case as far as present methods of measurements are concerned.

(1941)

The existence or nonexistence of "molecules" in glass is a much-debated topic. In a liquid like benzene or carbon tetrachloride, the forces within the C_6H_6 or CCl_4 groups are so strong as compared with those between these groups that the vapor densities, low liquid viscosities, and other physical properties point unequivocally to the existence of discrete molecules which have the stoichiometric composition of C_6H_6 or CCl_4. The expression, "continuous network of ions" is used in referring to silicate and similar glasses. This network, however, can not really be continuous because if this were true how could it flow and how

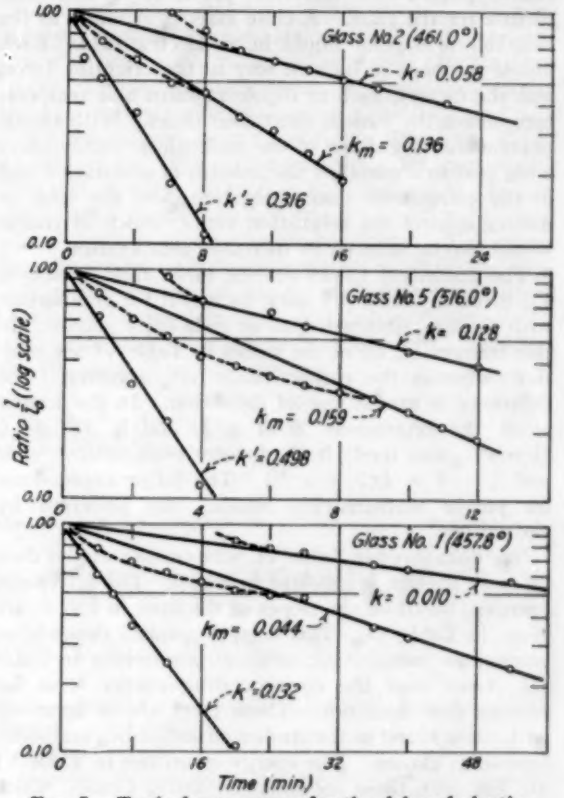

FIG. 5.—Typical rate curves for the delayed elastic process.

could it exhibit electrolytic conduction and show other properties that require actual displacement of ions with respect to one another? The weaker bonds in the system probably break, and in this way a small unit of matter actually becomes temporarily separated from the remainder of the liquid (or glass). During this short period, this matter has the properties of a molecule (or of an ion if it is electrically charged), and it should be so described. There are no weak bonds in fused silica, wherein O/Si equals 2. The whole mass therefore acts as a unit and has an extremely high viscosity up to very high temperatures where there is enough thermal energy to break a few bonds. The molecules in such a glass are very large in mass and in size and few in number. In a basic melt, however, such as Na_4SiO_4 or Na_6SiO_6, wherein O/Si equals or

exceeds 4, the silicate ion has the composition of SiO_4, that is, the molecules have very small mass and size and are very numerous. Such a melt has low viscosity, and it may not even have satisfactory vitreous properties. All intermediate cases are possible; long silicate chains, for example, are found in metasilicate crystals and probably exist in the melts. Unless all molecules in a silicate melt or glass have exactly the same size, which would be contrary to statistical and kinetic theory, the several sizes (and masses) will lead to several constants for the rate of orientation when the piece of glass is subjected to stress. The delayed-elastic phenomena therefore point to a molecular picture for the glass. A close analogy is found in the behavior of a polar liquid in an electric field. Each dipole responds in its own way to the orienting force, and the factors, such as dipole moment and temperature, affect the various relaxation times. With elastic phenomena, the shape of the molecule probably plays a big part in controlling the amount of orientation and in the consequent fiber elongation, and the sizes or masses control the relaxation times, which of course would also be reduced by increased temperature.

The numerical values for the mean rate constants, k_m, listed in Table VI may be useful for comparison with similar published data on soda-silica glasses. In this connection, all of the values in Table VI are positive, whereas the earlier values are negative. The difference is merely one of definition. In the former work, the expressions, $dl/dt = kl$ and $l_0 - l = l_0(1 - e^{kt})$, were used; in the present work, $-dl/dt = kl$ and $l_0 - l = l_0(1 - e^{-kt})$. The latter expressions, for purely mathematical reasons, are preferred by the writers.

The data given in Table VI, with certain similar data on other glasses, are plotted in Fig. 6. The activation energies, based on the slopes of the lines in Fig. 6, are given in Table VI. This energy quantity depends on percentage composition, although a reference to Table III shows that the corresponding energy term for viscous flow does not. These facts are in harmony with those found in the studies on soda-silica and soda-lime-silica glasses. The energy quantities in Table VI are less than those for soda-containing glasses, which range from 105,000 to 153,000 cal./N, wherein N represents 6.06×10^{23}, the Avogadro number of elementary processes.

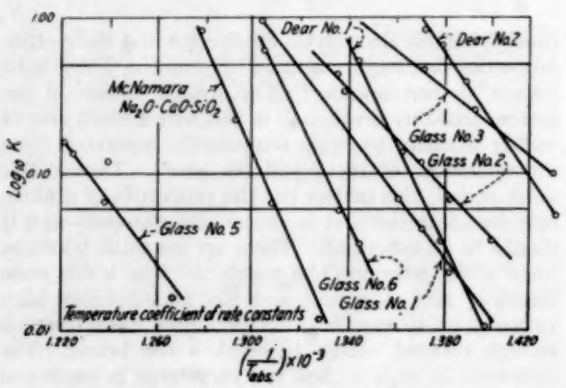

FIG. 6.—Effect of temperature on the delayed elastic process.

The expression, $-dl/dt = kl$, is the same in form as that used to describe radioactive decay. In the latter case, the term, "half-life" period, is the time during which the activity falls to one half its strength. The term, "relaxation time," similarly may be applied to the delayed elastic process. This is the time during which the quantity, l, falls from $l = l_0$ to $l = l_0/e$. Because, in general, $l = l_0 e^{-kt}$, the relaxation time is $t = 1/k$, which is obtained simply by taking the reciprocal of the rate constant. These times are shown in Table VI and also in Fig. 7; note that log t is proportional to $1/T$; therefore even at temperatures as high as 300°C., they are already extremely long. Glass No. 5 at 300°C., for example, would show a relaxation time of 10^9 minutes, which is roughly 2000 years. This means that strain is not readily removed from this glass at this temperature. The relaxation time, t, at 429°C. is only 11.5 minutes. These results are typical of glasses, and they indicate the great importance of proper heat treatment.

TABLE VI

MEAN RATE CONSTANTS FOR DELAYED ELASTIC PROCESS, $-dl/dt = k_m l$

Glass No.	Temp. (°C.)	k_m	1000/-$T°_{abs}$	Activation energy (cal./N)	Relaxation times (min.)
1	450.2	0.023	1.382		43.5
	457.8	.044	1.370		22.8
	476.0	.220	1.335		4.54
	494.0	.985	1.304	95,700	1.02
2	441.0	0.047	1.400		21.3
	451.0	.068	1.382		14.7
	457.8	.118	1.370		8.5
	461.5	.136	1.362		7.4
	474.2	.341	1.338		2.9
	476.0	.422	1.335	67,400	2.4
3	429.0	0.087	1.425		11.5
	445.8	.224	1.392		4.5
	457.8	.418	1.370	56,700	2.4
5	522.0	0.030	1.259		33.3
	533.5	.067	1.240		14.9
	543.0	.133	1.225		7.5
	545.8	.157	1.221	89,500	6.4
6	471.0	0.035	1.344		28.6
	475.0	.057	1.337		17.6
	494.0	.610	1.304	142,000	1.6

IV. Summary

Rates of elongation at the annealing temperature of stabilized potash-silica, potash-lime-silica, and soda-lime-silica glass rods, subjected to longitudinal tension, have been measured. The data have been analyzed into the following simultaneously operating phenomena: (1) instantaneous (or very rapid) elastic distortion, (2) delayed elastic distortion, and (3) pure viscous flow. The delayed elastic distortion, which is more complex than in soda-silica glasses, may be represented by two terms of the form, $l_0(1 - e^{-kt})$, rather than by a single term, which indicates that more than one kind

of "molecule" is oriented by the tensional stress. Under isothermal conditions, the equation for the entire elongation at any instant is expressed by the following equation:

$$E_t = I + l_0'(1 - e^{-k't}) + l_0(1 - e^{-kt}) + k_v t,$$

or more exactly by

$$E_t = I(1 - e^{-k't}) + l_0'(1 - e^{-k't}) + l(1 - e^{-kt}) + k_v t.$$

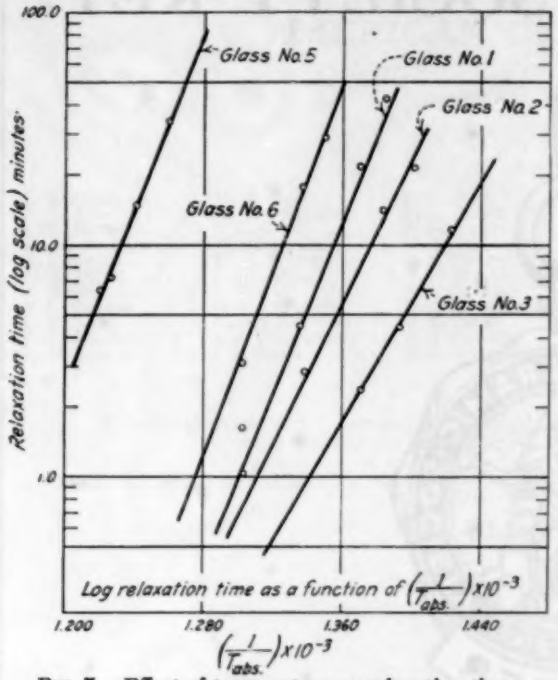

FIG. 7.—Effect of temperature on relaxation time.

For the delayed elastic process in these stabilized glasses, the rate of stress release is proportional to the stress, $-dl/dt = kl$, as suggested by Clark Maxwell. The rate constants have been evaluated as well as their reciprocals, that is, the "relaxation times." The temperature coefficient of the rate constants leads to activation energies in the potash-silica series, ranging from 57,000 to 96,000 calories, which are considerably lower than for corresponding soda-silica glasses.

Viscosities have been measured in the range of 10^{10} to 10^{14} poises. The activation energy for viscous flow (105,000 calories per mol) is independent of the percentage of potash or of silica, but it appears to be determined by the potassium-oxygen bond. The corresponding value for soda-silica glasses is 150,000 calories.

The mechanism of elastic deformation in these glasses is discussed in some detail from the molecular viewpoint, and some conclusions are drawn regarding the structure of such glasses.

DEPARTMENT OF CERAMICS
PENNSYLVANIA STATE COLLEGE
STATE COLLEGE, PENNSYLVANIA

FORTY-THIRD ANNUAL MEETING, AMERICAN CERAMIC SOCIETY

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TABLE OF ELAPSED TIME BETWEEN BALTIMORE AND PRINCIPAL CITIES IN UNITED STATES AND CANADA

	By rail		By air		Driving mileage		By rail		By air		Driving mileage
	Hr.	Min.	Hr.	Min.			Hr.	Min.	Hr.	Min.	
Atlanta, Ga.	17		4		728	Montreal, Que.	15	30	5	30	573
Boston, Mass.	8	45	2	50	413	New Orleans, La.	33		8	30	1259
Buffalo, N. Y.	10	30	3	15	378	New York, N. Y.	3	15	1	30	188
Charleston, S. C.	12		3	45	567	Norfolk, Va.	Overnight by boat				230
Chicago, Ill.	15	45	4	30	691	Oklahoma City, Okla.	34		10		1467
Cincinnati, Ohio	15	15	2	50	500	Omaha, Neb.	26		8		1161
Cleveland, Ohio	15	45	2	50	362	Philadelphia, Pa.	1	45		40	100
Dallas, Texas	36	45	7	50	1468	Pittsburgh, Pa.	7	30	1	40	232
Denver, Colo.	32		9	50	1726	Richmond, Va.	4		1	25	148
Detroit, Mich.	15	30	4	45	527	Salt Lake City, Utah	43		13	30	2281
Kansas City, Mo.	29		7	50	1064	San Francisco, Calif.	58		15	45	3069
Los Angeles, Calif.	56		15	30	2957	Seattle, Wash.	64		21		3001
Memphis, Tenn.	25	30	5	30	977	St. Louis, Mo.	20	45	5	40	811
Minneapolis, Minn.	23		7	40	1134	Toronto, Ont.	14		5	15	493
						Washington, D. C.		45		15	37

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March, 1941

20—3

Abrasives

Abrasive powders from Semiz-Bugu corundum. B. N. MOSKVIN. *Optiko Mekh. Prom.*, **10** [3] 10–19 (1940).—Grinding experiments are discussed, and results are tabulated. M.V.C.

Polishing and its phases. JOSEPH G. STERLING. *Metal Finishing*, **38**, 427–28 (1940); *Chem. Abs.*, **34**, 6885 (1940).—Ni deposits on well-polished steel are less porous than those of equal thickness on poorly polished steel. Observations and data on setting up polishing wheels and sequence of polishing are given.

PATENTS

Abrading apparatus, etc. J. E. BURNS. U. S. 2,228,386, Jan. 14, 1941 (March 20, 1939).

Abrading machine. L. W. GODDU AND J. H. SMITH (American Optical Co.). U. S. 2,228,563, Jan. 14, 1941 (May 25, 1938).

Abrasive article. C. E. BARNES (Norton Co.). Can. 392,342, Nov. 5, 1940 (March 17, 1939; in U. S. March 19, 1938). G.M.H.

Abrasive articles. TATURO HIRAI. Japan. 128,609, Feb. 3, 1939; *Chem. Abs.*, **34**, 8202 (1940).—An abrasive is mixed with rubber, made into a plate, coated with natural or synthetic resin and (or) its solution in a solvent with or without abrasive materials, coated with abrasive materials, and dried. This process is repeated several times, and the product is wrapped in parchment paper and vulcanized in a metallic mold.

Abrasive material. E. I. DU PONT DE NEMOURS & CO., INC. Fr. 845,536, Nov. 2, 1938. D.A.B.

Abrasive product. N. P. ROBIE (Carborundum Co.). U. S. 2,227,200, Dec. 31, 1940 (Oct. 30, 1939).

Abrasive product and grinding wheels. J. T. GROS. Fr. 853,954, Nov. 28, 1938. D.A.B.

Abrasive surface and method of preparing. F. F. GILMORE AND F. W. KOTLER (F. F. Gilmore). U. S. 2,226,607, Dec. 31, 1940 (June 7, 1938).

Abrasive wheel. R. C. BENNER AND W. G. SOLEY (Carborundum Co.). U. S. 2,225,193, Dec. 17, 1940 (Sept. 15, 1937).—An abrasive article comprises ceramic-bonded diamond containing inserts embedded in a rigid nonabrasive supporting matrix, the surface of which is substantially flush with the grinding surface of the adjoining inserts.

Apparatus for:

Cutting and polishing glass and metals. S. CLAVE. Fr. 835,191, Aug. 31, 1937. D.A.B.

Dressing grinding wheels. E. L. MEESON. Fr. 853,103, April 14, 1939. D.A.B.

Dressing grinding wheels for grinding or sharpening machines. H. H. ASBRIDGE AND CHURCHILL MACHINE TOOL CO., LTD. Fr. 835,443, March 19, 1938. D.A.B.

Finishing and reconditioning edged tools. J. E. BURNS. U. S. 2,228,385, Jan. 14, 1941 (Jan. 27, 1939).

Regulating the tension of abrasive bands on polishing machines, etc. M. J. DELIOT. Fr. 853,814, Nov. 15, 1938. D.A.B.

Apparatus and process for grinding. E. FOUQUET. Fr. 853,883, Nov. 22, 1938. D.A.B.

Bases for abrasives. BEHR-MANNING CORP. Fr. 833,160 to 833,164, Feb. 4, 1938. D.A.B.

Brake-shoe lining grinding machine. W. B. STONE. U. S. 2,225,806, Dec. 24, 1940 (Aug. 31, 1939).

Buffing or polishing wheel. L. W. MACFARLAND AND STEPHEN KRUGLOFF (L. W. MacFarland). U. S. 2,226,624 and 2,226,625, Dec. 31, 1940 (Nov. 28, 1939).

Buffing wheel. C. J. PETERSON AND A. H. PETERSON. U. S. 2,226,256, Dec. 24, 1940 (May 2, 1940).

Button-grinding machine. A. A. SCOTT, JR. (Patent Button Co.). U. S. 2,227,865, Jan. 7, 1941 (March 7, 1938).

Calcium silicate bonding method. N. P. PITT AND E. G. BAKER. Can. 392,845, Dec. 3, 1940 (April 6, 1938). G.M.H.

Cutter sharpener. C. T. GALLOWAY (Gleason Works). U. S. 2,224,959, Dec. 17, 1940 (June 29, 1938).

Device for dressing grinding tools. KARL TESSKY. U. S. 2,225,489, Dec. 17, 1940 (July 26, 1938).

Fine grinding wheels for cutting marble, etc. FOURS ROUSSEAU. Fr. 852,629, April 5, 1939. D.A.B.

Forming truing apparatus. JOHN OLSON (Norton Co.). U. S. 2,229,016, Jan. 14, 1941 (April 27, 1940).

Grinding of ball races. LANDIS TOOL CO. Brit. 529,610, Dec. 4, 1940 (June 17, 1938).

Grinding instrument. P. RAUZIÈRES. Fr. 835,422, March 18, 1938. D.A.B.

Grinding machine. E. FOUQUET. Fr. 853,927, Nov. 25, 1938. D.A.B.

Grinding ring. EDWARD VAN DER PYL (Norton Co.). U. S. 2,229,019, Jan. 14, 1941 (Sept. 5, 1939).

Grinding wheel. S. S. KISTLER AND C. E. BARNES (Norton Co.). Can. 392,626, Nov. 19, 1940 (Oct. 11, 1938; in U. S. Oct. 23, 1937). EDWARD VAN DER PYL (Norton Co.). Can. 392,625, Nov. 19, 1940 (Sept. 17, 1938; in U. S. Sept. 23, 1937). G.M.H.

Grinding wheel for soft materials. A. MONTAGNE. Fr. 834,979, March 8, 1938. D.A.B.

Hard-carbide composition. J. A. BOYER AND C. G. ROSE (Carborundum Co.). U. S. 2,225,152, Dec. 17, 1940 (Feb. 21, 1938).—A fused carbide composition consists essentially of boron carbide and a difficultly fusible carbide of the group consisting of titanium and zirconium carbides in which the difficultly fusible carbide is present as a separate crystalline phase which has solidified from a fused mass.

Honing and lapping machines. A. F. BURGESS (Barnes Drill Co.). Brit. 529,571, Dec. 4, 1940 (Oct. 25, 1939). CRAVEN BROS. (Manchester), LTD., AND J. H. RIVERS. Brit. 529,409, Dec. 4, 1940 (May 30, 1939).

Honing machines. A. F. BURGESS (Barnes Drill Co.). Brit. 529,567, Dec. 4, 1940 (Sept. 19, 1939).

Improvements of silicon carbide for abrasives. CARBORUNDUM CO. Fr. 851,453, March 10, 1939. D.A.B.

Irregular contour grinding machine. B. D. BROWN. U. S. 2,227,243, Dec. 31, 1940 (Sept. 30, 1936).

Lap. EDWARD VAN DER PYL (Norton Co.). U. S. 2,226,506, Dec. 24, 1940 (Oct. 2, 1940).

Machine for dressing cylindrical surfaces by a honing or lapping process. A. F. BURGESS (Barnes Drill Co.). Brit. 529,568 and 529,569, Dec. 4, 1940 (Sept. 19, 1939).

Machine for grinding bodies of rotation having curved generatrices. AKTIEBOLAGET SVENSKA KULLAGERFABRIKEN. Brit. 529,449, Dec. 4, 1940 (June 17, 1938).

Machine for grinding borings. H. H. ASBRIDGE AND CHURCHILL MACHINE TOOL CO., LTD. Fr. 835,444, March 19, 1938. D.A.B.

Machine for grinding sheet metal. A. DESNOULEZ. Fr. 833,002, Feb. 1, 1938. D.A.B.

Manufacture of abrasive-coated products. J. A. WILLIAMSON (Carborundum Co.). U. S. 2,225,937, Dec. 24, 1940 (May 23, 1939).

Manufacturing abrasive cylinders for polishing machines. D. E. MULHOLLAND. Fr. 831,773, Jan. 7, 1938. D.A.B.

Manufacturing synthetic resins. NORTON GRINDING WHEEL CO., LTD. Brit. 528,962, Nov. 27, 1940 (Jan. 28, 1938).

Polishing and dressing machine. SALAMAND & GRET (S. À R. L.). Fr. 834,177, Feb. 24, 1938. D.A.B.

Polishing wheels. R. PANIEN. Fr. 850,928, Sept. 6, 1938. D.A.B.

Precision grinding machine. M. JONES AND CHURCHILL MACHINE TOOL CO., LTD. Fr. 832,215, Jan. 18, 1938. D.A.B.

Preparing boron carbides. WALDEMAR KAUFMANN AND ALWIN KRAUSS (W. H. Duisberg). U. S. 2,228,923, Jan. 14, 1941 (July 23, 1938).

Pulpstone. THURE LARSSON (Norton Co.). Can. 392,624, Nov. 19, 1940 (Aug. 4, 1938; in U. S. Aug. 11, 1937). G.M.H.

Rotary grinding tool. PILKINGTON BROS., LTD. Fr. 846,391, Nov. 21, 1938. D.A.B.

Screw thread grinding machine. S. A. HORSTMANN. U. S. 2,227,715, Jan. 7, 1941 (Feb. 21, 1938).

Segmental abrasive wheel. H. W. H. BETH (Norton Co.). Can. 392,627, Nov. 19, 1940 (Oct. 27, 1938; in U. S. Nov. 3, 1937). G.M.H.

Sharpening device suitable for gramophone needles. A. G. IMHOF. U. S. 2,225,605, Dec. 17, 1940 (Jan. 12, 1940).

Sheeted cellulosic material and abrasive article and process of making. B. S. CROSS (Minnesota Mining & Mfg. Co.). U. S. 2,226,553, Dec. 31, 1940 (April 12, 1933).

Tap-grinding fixtures. ROBERTS, BLACK & CO., LTD., AND J. T. NEWBY. Brit. 529,327, Dec. 4, 1940 (May 30, 1939).

Tool head for grinding machines. H. L. BLOOD (Heald Machine Co.). U. S. 2,227,697, Jan. 7, 1941 (Jan. 14, 1938).

Art and Archeology

Application of photography in ceramics. WALTER D. FORD. *Bull. Amer. Ceram. Soc.*, **20** [1] 1–4 (1941).—11 references.

Art pottery as a means of rehabilitation. JACK M. SMOOT. *Bull. Amer. Ceram. Soc.*, **20** [1] 11–13 (1941).

Chinese porcelain at Freer Gallery of Art. GRACE DUNHAM GUEST. *Bull. Amer. Ceram. Soc.*, **20** [1] 22–25 (1941).—8 illustrations.

Chinese pottery industry three hundred years ago. SUNG YING-HSING. Translated from T'ien Kung K'ai Wu by Meng-chang Ling. *Bull. Amer. Ceram. Soc.*, **20** [1] 15–22 (1941).—A list of Chinese terms is given. 12 illustrations, 24 footnotes.

Construction and operation of the Harwell "groundhog" kiln. CONVERSE HARWELL. *Bull. Amer. Ceram. Soc.*, **20** [1] 10–11 (1941).—1 figure.

Hub of the wheel. LUCILLE SHATTUCK. *Bull. Amer. Ceram. Soc.*, **20** [1] 13–15 (1941).—1 reference.

Munsell Color System: Foreword. DEANE B. JUDD. *Jour. Optical Soc. Amer.*, **30** [12] 574 (1940).—These five papers are presented as a unit to bring out (1) the steps in the development of the ideas of Albert H. Munsell and (2) the relations and distinctions between psychological and psychophysical color systems. **History of Munsell Color System and its scientific application.** DOROTHY NICKERSON. *Ibid.*, pp. 575–86.—The life of the originator of the system, Albert H. Munsell (1858–1918), and the various organizations which grew from application and research on his ideas are traced through his diary and through technical publications from Munsell laboratories. **Analysis of original Munsell Color System.** J. E. TYLER AND A. C. HARDY. *Ibid.*, pp. 587–90.—Spectrophotometric data on 15 chromatic and nine neutral standards of the system have been integrated in accordance with the 1931 I.C.I. standard observer and Illuminant C. Attention is called to the remarkable scientific insight of Munsell. **Analysis of Munsell Color System based on measurements made in 1919 and 1926.** K. S. GIBSON AND D. NICKERSON. *Ibid.*, pp. 591–608.—An examination was made of the Munsell Color System as it existed in 1919 and 1926. The relation between Munsell value and luminous apparent reflectance, $V' = 100\,(Y - 0.007)$, has been confirmed in a general way. The relation between Munsell hue and dominant wave length depends upon the neutral point adopted, and the terms cannot be used interchangeably. A psychophysical system based on the Munsell instructions has been developed; it is compared with the psychological system being developed by the Newhall Subcommittee of the Optical Society. **Trichromatic analysis of the Munsell Book of Color.** J. J. GLENN AND J. T. KILLIAN. *Ibid.*, pp. 609–16.—The color system represented by the 1929 Munsell Book of Color (*Ceram. Abs.*, **9** [5] 330 (1930)) is compared with the system adopted in 1931 by the International Commission on Illumination. **Preliminary report of the Optical**

Society of America Subcommittee on the spacing of Munsell colors. S. M. NEWHALL. *Ibid.*, pp. 617–45.—The spacing problem consists in the detection and correction of errors of allocation in the surface-color space of the regular 1929 Munsell samples. For the last five years various observers have been making visual estimates of the color spacings, and the accumulated data are presented in tabular form. The data will provide a psychological basis for defining smooth contours of Munsell hue, value, and chroma in terms of the 1931 I.C.I. colorimetric coordinate system. This preliminary report includes charts of a preliminary smoothing of chroma based on the earlier visual estimates. A.P.

Principle of light reflectance applied to color matching. B. J. SWEO. *Enamelist*, **18** [1] 17–22 (1940).—A general discussion of color matching is given. S. presents diagrams showing energy distribution curves for daylight and incandescent light and spectrographic curves of various color samples. L.E.T.

BOOKS

Ceramic Processes. MARY CHASE STRATTON. Edwards Brothers, Inc., Ann Arbor, Mich., 1941. 77 pp.—This book for beginners in ceramics is presented on the ground of needed simplicity. Most treatises pertaining to clay and glazes either are quite technical or cover so large a field that the uninformed student despairs at the start. The added asset of scientific training makes the pursuit of the craft more intelligible, but a practical acquaintance with ceramic materials permits the development of an idea into an imperishable form. S. gives directions for clay preparation, methods of construction, making a box, use of slips, tile making, mold making, and the use of colored slips, together with glaze formulas. Each page is illustrated by drawings of prehistoric and historic ceramic ware, and a ceramic chronological chart is presented which indicates the "high spots" of ceramic culture. S. also attempts to awaken the student's interest in museums and collections.

Practical Pottery for Craftsmen and Students. R. HORACE JENKINS. Bruce Publishing Co., Milwaukee, 1941. 192 pp., 165 illustrations. Price $2.75.—Homecraftsmen are "rediscovering" pottery and learning that this time-honored craft makes a hobby of absorbing interest in artistic self-expression. In this complete, clearly written, methodically presented handbook, the beginner will find a reliable guide to every phase of pottery, from the selection of proper equipment and material to a quick, easy grasp of the basic processes. It is the result of the author's more than twenty years' experience as teacher and craftsman. It makes self-instruction possible for the worker of little experience, and the skilled craftsman will find it a source of many helpful hints and ideas.

J. explains essential operations and related information in proper sequence. A brief, informative sketch of the history of pottery is followed by discussions of the sources and varieties of clay and the essential steps in preparing it for modeling. The processes of hand building by the coil and strip methods are explained, and basic directions are given for designing and decorating, plaster of Paris and mold making, and the casting of covers, handles, spouts, etc. The important and fascinating process of throwing on the wheel is thoroughly explained, with complete illustrations of each step. J. also discusses turning, trimming, drying, throwing large pieces, tilemaking, pressing and making irregular shapes, biscuit firing, glazes and glaze composition, mat and fritted glazes, glazing, glost firing, recipes for glazes, and problems and defects encountered. One chapter deals with the equipment for a pottery shop, with cost estimates. A brief bibliography and a list of equipment, materials, and dealers are given.

For the past twenty-five years, Roy Horace Jenkins has been Professor of Industrial Education at Humboldt State College, Arcata, Calif. He is a graduate of Central State Teachers College, Edmund, Okla., and of Oregon State Teachers College, Corvallis, Ore.

During the past year, five books have been written by American authors for pottery craftsmen. Each is excellent but each is wholly different. Each should be in the library of pottery craftsmen. They are as follows: (1) Pottery Made Easy, by John Wolfe Dougherty (*Ceram. Abs.*, **19** [3] 60 (1940)), (2) Pottery of the American Indians, by Helen E. Stiles (*ibid.*, **18** [11] 290 (1939)), (3) Pottery; Its Craftsmanship and Its Appreciation, by Edmund deForrest Curtis (*ibid.*, **19** [10] 229 (1940)), (4) Ceramic Processes, by Mary Chase Stratton, Edward Bros., Inc., Ann Arbor, Mich., and (5) Practical Pottery for Craftsmen and Students, by R. H. Jenkins. Each of these books gives instructions in terms understood by secondary school pupils. Each of the authors is a successful teacher in ceramic studio pottery making. Practical Pottery is exceptionally well illustrated by pictures and descriptive matter. R. C. PURDY

PATENTS

Ceramic color and process of preparing. V. H. REMINGTON AND RAY ANDREWS (B. F. Drakenfeld & Co., Inc.). U. S. 2,225,659, Dec. 24, 1940 (Sept. 30, 1936).—The process of preparing a vitrifiable ceramic coloring material adapted to be applied to glassware, etc., comprises intimately mixing finely ground glass enamel with oil and a solvent for the oil and driving off the solvent.

Decorating porcelain. SEISAKU TAKEITI. Japan. 128,605, Feb. 3, 1939; *Chem. Abs.*, **34**, 8201 (1940).—Porcelain is coated with sirup, and a design is applied with paint containing gelatin. The edge of the design is moistened with soap solution, and the article is fired.

Designs for:

Bottle. M. E. NAGLE (Kimble Glass Co.). U. S. 124,328, Dec. 31, 1940 (Sept. 25, 1940).

Container for perfume. ABRAHAM LEVY. U. S. 124,636 to 124,642, Jan. 14, 1941 (Nov. 5, 1940).

Glass tumbler. FEDERAL GLASS CO. Can. 12,900, Nov. 16, 1940. G.M.H.

Jelly tumbler. W. J. LUNDY (Olean Glass Co.). U. S. 124,317, Dec. 31, 1940 (Aug. 23, 1940).

Milk bottle. W. C. TEUNISZ. U. S. 124,122, Dec. 17, 1940 (May 9, 1940).

Plate. C. W. LEIGH (Morimura Bros., Inc.). U. S. 124,624 to 124,630, Jan. 14, 1941 (Nov. 18, 1940). U. S. 124,631 to 124,635, Jan. 14, 1941 (Nov. 26, 1940). E. M. OTIS (Onondaga Pottery Co.). U. S. 124,107, Dec. 17, 1940 (Oct. 24, 1940).

Formation of colored decorations and of printing on enamel and glazes. E. P. SCHLEGEL (Deutsche Gold und Silber Scheideanstalt vorm. Roessler). U. S. 2,226,913, Dec. 31, 1940 (Feb. 23, 1937).—A process for preparing colored decorations and printing on enamels and glazes consists in grinding a lead-free ceramic color with a mixture of petroleum oil and a lubricating oil, applying the resulting color suspended in an oil vehicle to the crude unfired enamel to be decorated, and then firing together crude enamel and color in a single firing operation.

Cements

PATENTS

Apparatus and process for producing clinker cement. H. VANDERWERP. Fr. 831,907, April 22, 1937. D.A.B.

Cement containing sodium or potassium silicate. A. VALLET. Fr. 850,927, Sept. 6, 1938. D.A.B.

Cement or plaster. H. H. MORETON. U. S. 2,227,790, Jan. 7, 1941 (May 6, 1935).—A cement consists of a mixture of Portland cement, ground silica, hydraulic lime, and a natural silicate product native to the Mojave Desert region of California, the product being a gel-forming colloidal material containing approximately 14.07% of

magnesia and characterized by a high water absorptiveness and an inherent alumina content of approximately 0.82%, the alumina content being so low that the quantities of any aluminates or alumina silicates which may be formed within the mixture will be negligible.

Manufacturing alumina cement and aluminum sulfate cement. A. LAFUMA. Fr. 834,645, Aug. 3, 1937. D.A.B.

Vertical kiln for burning gypsum. P. BREUILLE, C. PÉTRÉ, AND A. SORCEL. Fr. 850,917, Sept. 3, 1938. D.A.B.

Enamel

Electrolytes in acid-resisting enamels. FRED A. PETERSEN AND CLARK HUTCHISON. *Jour. Amer. Ceram. Soc.*, 24 [2] 51–57 (1941).—7 tables, 16 references.

Silicates and their application to metal cleaning. K. P. BELLINGER. *Monthly Rev. Amer. Electroplaters' Soc.*, 27 [4] 267–74 (1940).—For metal cleaning, $2Na_2O{\cdot}SiO_2$, $Na_2O{\cdot}SiO_2$, and $Na_2O{\cdot}4SiO_2$, alone or blended with other cleaning agents, possess advantages over Na_2CO_3, NaOH, trisodium phosphate, and tetrasodium pyrophosphate, particularly with respect to available alkali (above pH 10), power of deflocculation and emulsification, buffer action, wetting characteristics, colloidal action, and rinsing properties. C.H.L.

Spectroscopic analysis of enamel frits. EUGENE WAINER AND EUGENE M. DUBOIS. *Bull. Amer. Ceram. Soc.*, 20 [1] 4–7 (1941).

BOOKS

Enameling Technique (Emailtechnik). LOUIS VIELHABER. V D I-Verlag, G.m.b.H., Berlin, 1939. 146 pp. Price 9 Rm.—The composition and use of enamels are considered, beginning with the raw materials, types of enamels, and manufacturing processes. The mechanical, thermal, chemical, and optical properties of enamels are discussed. The application, drying, and firing of enamels on sheet steel and cast iron are described, including operation, control, and likely errors. F.G.H.

Proceedings of the Porcelain Enamel Institute Forum, Fifth Forum, October, 1940. Porcelain Enamel Inst., Inc., Chicago, 1940. 153 pp. Price $2.00; complete set of proceedings of the five forums, $4.00.—Separate abstracts of papers in the proceedings will be published in the April issue of *Ceramic Abstracts*.

PATENTS

Ceramic enameling process. COMPAGNIE GÉNÉRALE D'ELECTRO-CÉRAMIQUE. Fr. 851,038, March 1, 1939. D.A.B.

Dry enameling process. VEREINIGTE CHEMISCHE FABRIKEN KREIDL, HELLER & CO. Fr. 852,428, March 31, 1939. D.A.B.

Manufacture of opacified enamels and glasses by means of gas. VEREINIGTE CHEMISCHE FABRIKEN KREIDL, HELLER & CO. Fr. 852,381, March 30, 1939. Fr. 852,429 and 852,430, March 31, 1939. D.A.B.

Preparing opacified vitreous enamels. SOC. DE PRODUITS CHIMIQUES DES TERRES RARES. Fr. 853,482, April 25, 1939. D.A.B.

Glass

Absorption spectra of glasses of different composition colored with the oxides of copper, iron, manganese, chrome, cobalt, nickel, uranium, and selenium. V. V. SURODEIKIN. *Optiko Mekh. Prom.*, 10 [3] 5–9 (1940).—Potassium glasses containing 3% CuO have a lower absorption than soda glasses in the red end of the spectrum and a similar or greater absorption in the violet part. Curves of potassium glasses with 4% Fe_2O_3 are always below those of soda glasses, i.e., iron is a stronger colorizer in soda glasses. Curves of Mn_2O_3 (3%) glasses are unstable due to an unequal degree of oxidation of this colorizer in the glass. In almost all cases (except in the case of baryta glass), curves of soda glasses are above the curves of potassium glasses, i.e., soda glasses are colored better than potassium glasses. Almost all Cr_2O_3 (0.75%) glasses have the same character of absorption (minimum 550$\mu\mu$ and maximum 650$\mu\mu$). Curves of absorption of Co (0.072%) glasses have three characteristic maxima and two minima. PbO and BaO glasses have a greater absorption in the middle part of the spectrum than other glasses. Curves of absorption of potassium glasses colored with NiO (0.2%) are very different from those of soda glasses with NiO. Glasses colored with UO_3 (2%) have a similar index of refraction. The coloring of Se glasses is varied. PbO glasses are yellow, calcium and baryta glasses have varying shades, soda glasses are yellow-brown, and potassium glasses are pale pink. Zinc, manganese, and boron glasses are colorless. With repeated heating to the softening point, glasses colored with Se did not change color. M.V.C.

Acoustical properties of glass. K. SCHUSTER. *Glastech. Ber.*, 18 [8] 213–20 (1940).—A detailed theoretical discussion is given. J.F.H.

Analysis of strains and stress in glass: I, Polarized light and polariscopes. A. J. MONACK AND E. E. BEETON. *Glass Ind.*, 20 [4] 127–32 (1939).—Fundamental laws governing the production and use of polarized light are reviewed, and various types of polariscopes are discussed. **II, Polarized light in strained glass.** *Ibid.*, [5] 185–91.—The action of strained glass on polarized light is discussed. The use of colors and dark areas produced in the polariscope to determine the amount and kind of strain present is shown. **III, Measuring instruments and stress systems.** *Ibid.*, [6] 223–28.—The construction and use of the graduated quartz wedge, the Babinet compensator, and a polarimeter for extreme accuracy are described. The analysis of single and combined stress systems in glass is discussed. **IV, Principal stresses and their evaluation.** *Ibid.*, [7] 257–62.—Isochromatic and isoclinic lines and their significance, lines of principal stress, and methods for evaluation of stresses in glass are explained. The construction and the use of a circular polariscope are outlined. See "Glass strains . . .," *Ceram. Abs.*, 17 [11] 350 (1938). A.P.

Bausch and Lomb optical instruments. ANON. *Fortune*, 22 [4] pp. 76–80, 98–103 (1940).—The inauguration and development by this American firm of the production of the highest grade optical glass in the U. S. is presented. With the present enormous demand for military instruments, especially the highly complex range finders, the production of precision lenses, prisms, etc., reaches paramount importance. The manufacture of optical glass is a highly arcane process requiring years of experience. Ingredients such as quartzite, lime, soda, potash, borax, antimony, arsenic, barium, etc., are weighed and mixed according to a secret formula. The batch is charged into preheated clay pots and fused in a large regenerative gas furnace for 7 or 8 hr. till it becomes a viscous, incandescent mass. It is then stirred with a preheated clay stirring rod of the same material as the pot for 16 hr., during which time the temperature is lowered till the melt has the consistency of molasses. The optical (slab) glass is left in the pot, but the latter is removed from the furnace, encased in an insulated cylinder, and left to cool slowly to room temperature for 3 to 5 days. The pot is then knocked apart, and the glass is broken into large chunks. Out of a 600-lb. melt, about 25 lb. will survive the processing and inspection to become lenses and prisms. M.V.C.

Bottles for internal vacuum. F. W. PRESTON. *Glass Ind.*, **21** [12] 523 (1940).—When dealing with the new lightweight containers, perfect distribution and excellence of glass quality are not in themselves enough to provide good bottles for use with vacuum. The designer must familiarize himself with the stress factors involved, especially in the case of noncircular shapes. Manufacturers of glass building blocks have encountered the same problem and have redesigned the block to reinforce the critical zones. A.P.

Briquetting batch. M. S. KAZANSKIĬ AND I. G. KLOCHKOV. *Stekolnaya Prom.*, **15** [7] 15–17 (1939).—Briquetting of the batch is performed on rollers having a surface speed of not more than 0.1 m. per sec. and a diameter of about 500 mm. The ingredients are mixed in an Eirich mixer. Cullet is crushed in a Blake-type crusher to a grain size not larger than 10 mm. In briquette batches, $CaCO_3$ is partly replaced by $Ca(OH)_2$. The batch is moistened in the mixer with lime milk of a definite concentration and amount which should be determined experimentally. The briquettes are dried with waste gases from the furnace with a resulting carbonization of slaked lime. M.V.C.

Chemical durability requirements of pharmaceutical containers. E. B. CARTER. *Glass Ind.*, **20** [10] 371–72 (1939).—Manufacturers and users of glass containers need a common ground for discussing chemical durability tests. An inexpensive glass is needed which will not be decomposed by aqueous solutions at pH 10 to 11 at room temperature. In certain cases where borosilicate glass would be too expensive, a satisfactory product is obtained by treating the inside surfaces of soda-lime glass with hot acid. The Bureau of Animal Industry and the National Formulary tests are recommended even though they measure the durability of the inner surface (*Bull. Nat. Formulary Committee*, **7**, 160–61 (Feb., 1939)). See "Pharmaceutical . . .," *Ceram. Abs.*, **13** [10] 255 (1934). A.P.

Conduction of electricity in simple mixed alkali glasses. BELA VON LENGYEL. *Glastech. Ber.*, **18** [7] 177–82 (1940).—The glass samples were prepared from pure SiO_2, Na_2CO_3, and K_2CO_3 with a constant alkali-silica ratio of 1/2. Resistance measurements were made on 3-mm. rods in vacuum at temperatures up to 500°. Transference numbers were determined by analyzing the alkali metals electrolyzed through the test samples in tube form from a heated KNO_3-$NaNO_3$ bath. The transference measurements established the fact that there is no essential difference in the mechanism of conduction of K+ and Na+. The deviation of the transference curves from a straight line is ascribed to size and polarization effects. J.F.H.

Corrugated glass for roofing. ANON. *Glaces & Verres*, **13** [63] 8–9 (1940); *Jour. Soc. Glass Tech.*, **24** [103] 161A (1940).—The St. Gobain Co. makes corrugated glass for use with corrugated asbestos roofing. Its surface is similar to that of cathedral glass, giving reasonable light diffusion, and the corrugation imparts great strength, a sheet 125 x 92 cm. supported on 110-cm. centers bearing a uniformly distributed load of 1000 kgm. per sq. m. It is particularly recommended for use in works and agricultural buildings, dwelling houses, and verandas.

Decoloring glass without decoloring agent. L. SPRINGER. *Glashütte*, **70** [46] 597–98 (1940).—If decoloring agents with a physical decoloring action (pyrolusite, nickel oxide, or selenium) cannot be obtained, the decoloring of glass with saltpeter and arsenic or antimony oxide or their substitutes is recommended. A mixture which has good decoloring action contains magnesium chloride with barium superoxide and fluorides such as sodium fluoride, sodium fluosilicate, and fluorspar which also act as good refining agents. S. discusses a proposition concerning the supplementary decoloration of glass by exposure to natural or artificial light. This is a difficult undertaking in practice because it is necessary to determine what secondary constituents a glass should contain to favor decoloration and other factors. In the case of iron it is necessary to know whether the divalent or the trivalent state is preferable and whether glasses with low iron content can be decolored by this means alone. A series of experiments were made by Eckert and Schmidt (*Ceram. Abs.*, **11** [5] 295 (1932)) on the fading of glasses containing cerium and arsenic in ultraviolet light. In an ordinary alkali-lime glass containing cerium, saltpeter produces no fading; arsenic causes fading even without the addition of cerium (*ibid.*, **19** [4] 88 (1940)). M.V.C.

Discussion on "Glass-fracture velocity." H. SCHARDIN. *Glastech. Ber.*, **18** [9] 233–36 (1940); see *Jour. Amer. Ceram. Soc.*, **22** [9] 302–307 (1939). J.F.H.

Dual-purpose lehr. ANON. *Glass Ind.*, **20** [10] 367–69 (1939).—Operations at the Johnston Glass Co., Hartford City, Ind., include both the processing and decorating of flat glass. A special continuous lehr which can be used for either decorating or annealing has been installed. 6 photographs. A.P.

Early glassmaking in Virginia. WALTER J. SPARKS. *Glass Ind.*, **20** [10] 373–75 (1939).—S. discusses Polish and Italian glassmakers at Jamestown. A.P.

Effect of heat treatment on color of gold-ruby glass. A. E. BADGER, W. WEYL, AND H. RUDOW. *Glass Ind.*, **20** [11] 407–14 (1939).—A series of eight soda-lime and potash-lead glasses containing 0.0075% Au was first melted for visual comparisons. The glasses obtained were then heated for 9 hr. at temperatures of 450° to 750°C. The richest color was developed in the potash-lead glass. Glasses containing Al_2O_3 required higher temperatures for developing the ruby color, presumably because of their greater viscosity. The formation of ruby in a commercial soda-lime glass is dealt with. Fragments were heated for various periods of time at temperatures of 575° to 1000°C. At the lower temperatures, purple tints developed. Intermediate temperatures produced ruby glasses. Glasses heated at the highest temperatures were blue by transmitted light and had a liver color by reflected light. Absorption curves of these glasses, measured with a precision spectrophotometer, can be used to predict the most favorable commercial heating schedule. The various colors were explained as follows: When the quenched (colorless) gold glass is heated near its softening temperature, the aurous compounds decompose and form the trivalent ion and metallic gold. The presence of reducing agents, e.g., stannous ion, aids this reduction. The gold atoms probably grow first as "trees" which cause purplish tints. These minute "trees" gradually change into more symmetrical forms, and the ruby color is produced. Further heat treatment causes these forms to aggregate into clusters which are responsible for the blue and liver colors. A.P.

Facilitating filtration. G. W. PAWEL. *Chemist-Analyst*, **29** [4] 93 (1940).—A thin layer of glass wool below the asbestos pad in Gooch crucibles speeds up filtering. A.P.

Fiber-glass insulation. HENRY SUSKI. *City Coll. Vector* [N. Y.], **3**, 29, 36 (1940); *Chem. Abs.*, **34**, 8192 (1940).—S. discusses the commercial production, dielectric strength, and physical properties of glass fibers and their use for insulating purposes.

Flat glass markets. D. H. GOODWILLIE. Read before National Glass Distributors' Assn., Dec., 1940; abstracted in *Amer. Glass Rev.*, **60** [11] 17–20 (1940). A.P.

Gall formation in glass. H. JEBSEN-MARWEDEL. *Glastech. Ber.*, **18** [7] 184–85 (1940).—Aside from the corrosive action on refractories, an interaction between the gall and the melt results in the extraction of some glass constituents, causing bubbles and striae as deep as 5 mm. J.F.H

Glass, an age-old art goes modern. ANON. *People & Places*, Dec., 1940.—Photographs show the vital steps in the manufacture of fine glassware from the mixing of the raw batch ingredients to the engraving of monograms. Scenes in the manufacture of glass cloth and glass block are also illustrated.

Glass siphon. SAXON COLE. *Chemist-Analyst*, **29** [4] 92 (1940).—To eliminate the difficulty of corrosion with

rubber stoppers, a glass bulb is blown in the glass tubing at a place where it will seal the bottle. A.P.

Index of refraction of a glass surface. A. VAŠIČEK. *Sklářské Rozhledy*, **16** [1] 9–17 (in English pp. 17–18) (1939); abstracted in *Glashütte*, **70** [46] 601 (1940); see "Artificially . . .," *Ceram. Abs.*, **19** [1] 8 (1940). M.V.C.

Making spectacle lenses at American Optical Co. ANON. *Glass Ind.*, **22** [1] 20–22 (1941).—Operations at the Southbridge, Mass., plant of the American Optical Co. are shown in 17 photographs. A.P.

Meaning of color in the polariscope. A. J. MONACK. *Glass Ind.*, **21** [12] 513–14 (1940).—The glass technologist who determines the stress distribution of a glass article from observation of color bands through the polariscope may easily be led to false conclusions unless he knows just what deductions may safely be drawn. Precise stresses can usually be determined only by integration along a line of principal stress. Even when the colors in some part of the article are low in the scale, there is no assurance that dangerous stresses are not present. A.P.

Meaning of testing procedures. F. W. PRESTON. *Glass Ind.*, **22** [1] 23–25 (1941).—The scientific development of standardized procedures for testing glass containers for mechanical strength in recent years has led to improved manufacturing techniques which in turn call for further developments in testing procedure. Thermal shock tests were first thought to test homogeneity. It has been found, however, that they disclose manufacturing defects. Hydrostatic pressure tests were regarded as tests for thin spots but were found to reveal bruises, chill checks, shear marks, etc. Thin spots near the Murgatroyd belt are more vulnerable to impact than to internal pressure. An impact test is being developed. Fracture diagnosis is important. A bottle is too complicated to be assessed by any one test. The testing department personnel must be alert to the changing significance of their tests. A.P.

Melting rate of soda-lime-silica glasses as influenced by composition and effect of minor constituents. J. C. POTTS. *Jour. Amer. Ceram. Soc.*, **24** [2] 43–50 (1941).—16 figures, 8 tables, 1 reference. See "Comparison . . .," *Ceram. Abs.*, **19** [4] 89 (1940).

Nomogram for evaluating the melting capacity and fuel consumption of glass tanks. R. GÜNTHER. *Glastech. Ber.*, **18** [7] 185–88 (1940). J.F.H.

Photographing of firing operations. PAUL NEUBERT. *Glastech. Ber.*, **18** [9] 245–46 (1940).—A long lens system enclosed in a water-cooled jacket is used in front of the camera. J.F.H.

Physics and windows in wartime. H. MOORE. *Jour. Sci. Instruments*, **17** [10] 237–41 (1940).—M. discusses the obscuration of all artificial lighting at night, the protection of windows against fracture due to blast, and the prevention of personal injury resulting from flying pieces of glass when windows are broken either by blast or by splinters. 4 figures. J.L.G.

Plate-glass manufacture. WILLIAM OWEN. *Glass Ind.*, **21** [12] 520–21 (1940).—The various processes involved in plate-glass manufacture are ingeniously diagrammed under the following headings: mixing, melting, annealing; grinding and polishing; and cutting, inspection, and shipping. A.P.

Possibilities of replacement of boric acid and lead oxide in technical glasses. M. THOMAS, H. KALSING, M. WAGNER, AND J. ENSA. *Glastech. Ber.*, **18** [8] 210–13 (1940).—Compositions which are satisfactory in certain technical applications are presented, and their properties are briefly discussed. J.F.H.

Production of transparent quartz glass in an electric furnace with bar electrodes. N. V. SOLOMIN. *Keram. & Steklo*, **14** [5] 21–24 (1938).—Experiments prove that it is possible to produce satisfactory transparent quartz glass for medical mercury lamps. This glass is also suitable for the manufacture of chemical ware. Theoretical assumptions of the melting process are confirmed by experiments. It is possible to improve the melting process further. M.V.C.

Separation of inhomogeneities in bottle glass by density differences. JOHN C. TURNBULL. *Jour. Amer. Ceram. Soc.*, **24** [2] 37–43 (1941).—3 figures, 4 tables, 5 references.

Story of glass. JOHN D. BIGGERS. *Glass Ind.*, **20** [11] 422 (1939).—In a radio interview, B. outlined some of the contributions of the glass industry to our social and economic welfare. A.P.

Strain viewer for the glass industry. T. ZIENER. *Glas & App.*, **20**, 113–15 (1939); *Jour. Soc. Glass Tech.*, **24** [103] 165A (1940).—In a large-field strain viewer manufactured by Zeiss, a polarizing filter, e.g., Polaroid, placed over the aperture in a lamp house gives a large source of polarized light. The operator wears goggles glazed with the same material, and the use of a separate analyzing prism is therefore unnecessary. See "Testing . . ." *Ceram. Abs.*, **19** [3] 64 (1940); "Strain . . .," *ibid.*, **20** [1] 23 (1941).

Surface tension of glasses: I. G. KEPPELER AND A. ALBRECHT. *Glastech. Ber.*, **18** [8] 201–10 (1940).—The results obtained by previous investigators are tabulated. The various methods are discussed and compared. **II.** *Ibid.*, [9] 236–45.—The methods involving bubble pressure, drop weight from a capillary, fiber contraction, and drop weight from a melted fiber were compared using the same glass. A smooth temperature-surface tension curve is formed using the bubble-pressure method values above the temperature where $\log \eta = 3.6$ and the lower temperature values of Berggren and Jaeckel obtained by the fiber contraction method. The values by both the drop weight methods are more scattered. The method of Pietenpol (*Ceram. Abs.*, **15** [8] 235 (1936)) may be useful in the viscosity range encountered between 700° and 1150°. J.F.H.

Use of slow motion photography in improving the glass-making process. R. F. HATCH. *Glass Ind.*, **22** [1] 11–16 (1941).—With slow motion photography the speed of glass-forming machinery can be reduced to a point where deliberate observation is possible. Faulty adjustments and imperfect timings are uncovered, and their effects upon the finished ware are predictable. Pointers in technique based on the experiences of the Hartford-Empire Co. are described. A.P.

Vessels and pipes made from Jena (Pyrex brand) glass for technical uses. P. H. PRAUSNITZ. *Schweiz. Arch. Angew. Wiss. Tech.*, **6** [9] 253–61 (1940).—Pyrex brand glass is used extensively for chemical reactions in flasks with a capacity up to 70 liters, vessels with a capacity up to 80 liters, heat exchangers, cooling coils, and pipe lines. A one-piece cooling coil has a diameter of 30 mm., 41 windings of 550 mm. diameter, a total height of 4 m., and a total length of 70 m. A chlorination tower is built by using 18 elements in series, each element being 510 mm. in diameter and 530 mm. long. Resins are being used increasingly for pipe connections. As packing material, Buna has replaced rubber to a great extent. The glass is used for vacuums up to 10^{-4} mm. Hg and for pressures up to 735 lb. per in.^{2}. The glass is able to withstand to some extent shocks caused by shutting off the liquids, and rapid heating up is not as dangerous as too-rapid cooling. See "Apparatus . . .," *Ceram. Abs.*, **18** [9] 236 (1939). J.M.N.

Vitrolite glass decoration. ANON. *Glass Ind.*, **20** [11] 401–405 (1939).—Near Parkersburg, West Virginia, the Libbey-Owens-Ford Glass Co. maintains a decorating department to produce the varied types of decorated work which can be combined with colored glasses and mirrors for installations such as that in the Forum Cafeteria in Chicago. Seven techniques are described. 13 photographs. A.P.

Warehouse system at Buck Glass Co. ANON. *Glass Ind.*, **21** [12] 515–18 (1940).—A warehouse and truck-loading dock recently constructed at some distance from the factory building utilizes an ingenious roller conveyer system which also serves the factory, decorating department, and rail shipping platform. 12 photographs. A.P.

Welding metal to glass. ANON. *Glass*, **17** [11] 342–46 (1940); *Electrician*, **125** [3260] 268 (1940); *Mech.*

World & Eng. Record, **108** [2811] 357–58 (1940).—Life tests at overloads of electric heaters made under a patented process by means of which metal is welded to glass show that, over a period of three years, there is no appreciable change of resistance, and it appears that the expected life of such heaters is very great. The heaters are made by spraying aluminum in a zigzag pattern onto the glass; an electric current is then passed through the long conducting path so formed. This heats the aluminum pattern and, by conduction, the glass. Tests to insure uniformity of product are described. A three-year test is claimed to have proved that a sprayed element has 16 times the normal life of a wire-wound element. See "Adherence . . . ," *Ceram. Abs.*, **17** [9] 301 (1938).
B.C.R., H.K.R., F.E.S.

Windows for defense. W. M. B. Sine. Read before National Glass Distributors' Assn., Dec., 1940; abstracted in *Amer. Glass Rev.*, **60** [11] 20 (1940). A.P.

Working of laminated glass. Anon. *Diamant*, **62**, 2–3, 12–13, 21–22 (1940); *Jour. Soc. Glass Tech.*, **24** [103] 161A (1940).—The preparation of a motor-car windshield in laminated glass is described with illustrations. In grinding, the sheet should not be held vertically above the horizontal stone but at an angle. A cork wheel at 300 r.p.m. is suitable for polishing with pumice. If holes must be bored, a tubular drill is best, working from each side to the plastic layer and taking great care that the two holes register exactly with each other. The plastic is then cut away with a sharp knife or removed by a hot nail, and the edges of the hole are smoothed with a silicon carbide countersink. In fitting to the windscreen frame, deep narrow notches in the sheet to avoid screw holes in the frame are bad as they weaken the glass. A linear rubber channel section is recommended, and in fitting the frame to the glass over this section, care is needed to avoid bending the metal and thus producing dangerous pressure points when the windshield is finally assembled. After fitting, the edges should be sealed by a suitable composition. The need for fitting wipers to the windshield without drilling the glass is stressed.

BOOK

National Foundation for Scientific Research and Industry (Fonds National de la Recherche Scientifique et L'Industrie). Pierre Beghin. Brussels, 1939. 408 pp. Reviewed in *Glass Ind.*, **20** [10] 366 (1939).—B. summarizes the activities of research workers of the Foundation with particular reference to sheet glass and colored glasses. A.P.

PATENTS

Acid-resisting glass flux. A. J. Deyrup (E. I. du Pont de Nemours & Co.). U. S. 2,225,159, Dec. 17, 1940 (March 17, 1937).—A low-melting lead borosilicate glaze composition suitable for application to glass or other ceramic ware to be decorated and having a fusing point below about 1100°F. has the following composition: lead oxide 50 to 75, silica 12 to 25, boric oxide 1 to 10, and titanium dioxide 1 to 8%, the titanium dioxide being incorporated by fusing with the other ingredients of the glaze, the proportions being by weight based on the weight of the melted flux.

Alkali silicates. Floridienne J. Buttgenbach & Co. Fr. 853,480, April 25, 1939. D.A.B.

Apparatus for:

Controlling the rolling and spreading of rollers in the continuous production of sheet glass. Forges & Ateliers de Constructions Électriques de Jeumont. Fr. 851,363, March 8, 1939. D.A.B.

Cooling the rollers in the rolling equipment of glass and glazing works. Forges & Ateliers de Constructions Électriques de Jeumont. Fr. 851,822, March 18, 1939. D.A.B.

Drawing glass fibers. C. G. Staelin (Owens-Corning Fiberglas Corp.). U. S. 2,225,667, Dec. 24, 1940 (July 24, 1936).

Guiding and combining glass fibers to produce wicks, ribbons, etc. Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey. Fr. 852,445, April 1, 1939. D.A.B.

Manufacturing bottles. D. O. Headley (Hazel-Atlas Glass Co.). U. S. 2,226,905, Dec. 31, 1940 (Feb. 14, 1938).

Manufacturing multicellular glass. Corning Glass Works. Fr. 845,805, Nov. 8, 1938. D.A.B.

Polishing spherical, elliptical, and cylindrical surfaces. Félix Oswald Maschinenfabrik. Fr. 830,805, Dec. 14, 1937. D.A.B.

Tempering plate or sheet glass. V. Seillier, M. Depinoix, and J. Viard. Fr. 853,006, Oct. 28, 1938. D.A.B.

Vertical drawing of sheet glass. N. V. Hollandsche Mij. voor de Vervaardiging van Glas. Fr. 846,540, May 27, 1938. D.A.B.

Apparatus and process for:

Automatic feeding of furnaces for manufacturing glass fibers and filaments. Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey. Fr. 852,292, March 29, 1939. D.A.B.

Continuous manufacture of glass tubes, etc. Compagnies Réunies des Glaces & Verres Spéciaux du Nord de la France. Fr. 853,872, Nov. 19, 1938. D.A.B.

Manufacturing glass fibers. Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey. Fr. 852,503, Oct. 8, 1938. Fr. 852,600, April 6, 1939. D.A.B.

Manufacturing hollow and sealed glass objects. Corning Glass Works. Fr. 851,062, March 2, 1939. D.A.B.

Treating vitreous quartz objects. F. Skaupy and G. J. Weissenberg. Fr. 830,931, Dec. 17, 1937. D.A.B.

Apparatus for tempering glass which conforms to the curvature of the glass. Compagnies Réunies des Glaces & Verres Spéciaux du Nord de la France. Fr. 845,786, May 6,1938. D.A.B.

Asbestos and glass fiber yarn. D. C. Simpson (Fiberglas Canada, Ltd.). Can. 392,471, Nov. 12, 1940 (May 6, 1938; in U. S. May 22, 1937). G.M.H.

Assembling pieces of toughened glass. Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey. Brit. 529,098, Nov. 27, 1940 (May 14, 1938).

Blower for the manufacture of glass fibers. Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey. Fr. 852,614, April 5, 1939. D.A.B.

Bonding fiber glass with carbon. J. F. Hyde (Owens-Corning Fiberglas Corp.). U. S. 2,225,009, Dec. 17, 1940 (Aug. 25, 1937).—The method of forming a porous fibrous mass comprises coating a plurality of silicate fibers with an organic adhesive which will form a carbonaceous residue upon heating and contains an agent tending to promote carbonization of the adhesive, causing the fibers to become adhesively attached to one another by means of the coating, and reducing the adhesive to an inert carbonaceous residue by moderately heating the bonded mass of fibers in the absence of oxygen while maintaining the adherence of the adhesive with the fibers.

Building block. Erle T. Putnam (Libbey-Owens-Ford Glass Co.). Can. 392,919, Dec. 3, 1940 (May 8, 1939). G.M.H.

Coating glass with precious metals. Krétatermékgyár Kft. Hung. 123,936, June 15, 1940; *Chem. Abs.*, **34**, 7561 (1940).—The glass surface is cleaned, freed from fat, and coated with a gasoline or benzene solution of rubber or resin, the metal is applied in thin sheets or by spraying, the surfaces are dried, and another layer of the precious metal is applied by electrolysis or galvanizing.

Coloring vitreous articles. GERALD WHITE (Libbey-Owens-Ford Glass Co.). U. S. 2,225,729, Dec. 24, 1940 (April 29, 1938).

Composite glass and ceramic article. ALFRED UNGEWISS (Steatit-Magnesia A.-G.). U. S. 2,227,770, Jan. 7, 1941 (Dec. 10, 1936).—A composite body consisting in part of a glass member of easily fused lead glass fused to a member of a ceramic material containing at least two constituents of the system MgO–Al_2O_3–SiO_2 having a coefficient of thermal extension of between 6 and 10 $\times$ 10^{-6}.

Design for glass joint member. R. S. FISH (Corning Glass Works). U. S. 124,649, Jan. 14, 1941 (Feb. 26, 1940).

Design for paste mold glass machine. F. W. STEWART, M. J. KELLY, AND A. J. REEK (Kelly Foundry and Machine Co.). U. S. 124,656, Jan. 14, 1941 (Aug. 27, 1940).

Drawing of table or sheet glass, especially of the fused mass. DEUTSCHE TAFELGLAS A.-G. Fr. 852,427, March 31, 1939. D.A.B.

Drilling machine suitable for glass. P. L. ZEHNTER. Fr. 834,493, July 26, 1937. D.A.B.

Drinking glass. ÉTABLISSEMENTS BARBIER FRÈRES. Fr. 852,300, March 29, 1939. D.A.B.

Electric furnace for melting glass. E. V. BOREL (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey). U. S. 2,225,616, Dec. 24, 1940 (Aug. 10, 1937).—In a glassmaking furnace wherein the flow of the glass is from one end of the furnace to the other, a plurality of electrodes in the furnace and means connecting the electrodes to a source of electrical energy whereby current is caused to flow through the glass between the electrodes, at least one of the electrodes being mounted in the furnace between the points of insertion of the glassmaking materials and of removal of the glass and wholly below the surface of the glass bath so that the glass may flow above and below it, the last-named electrode extending across substantially the entire width of the furnace.

Electric furnace for melting glass. EGYESÜLT IZZÓLÁMPA ÉS VILLAMOSSÁGI RESZVENYTARSASAG. Fr. 853,292, April 21, 1939. D.A.B.

Electric fusion furnace to be used in the manufacture of glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 851,630, Sept. 17, 1938. D.A.B.

Electric heating of liquid baths. E. V. BOREL (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey). U. S. 2,225,617, Dec. 24, 1940 (June 14, 1938).

Equipment for tempering glass. AMERICAN SECURIT CO. Fr. 851,594, March 14, 1939. D.A.B.

Fibrous glass felt. GAMES SLAYTER (Fiberglas Canada, Ltd.). Can. 392,900, Dec. 3, 1940 (Dec. 9, 1937; in U. S. Dec. 24, 1936). G.M.H.

Fixing glasses or silvered glasses onto their support. SOC. MARLY FRÈRES. Fr. 832,058, Jan. 14, 1938. D.A.B.

Forming hollow glass articles. G. E. ROWE (Hartford-Empire Co.). U. S. 2,226,504, Dec. 24, 1940 (Feb. 23, 1938).

Furnace structure. G. V. MCCAULEY (Corning Glass Works). U. S. 2,228,395, Jan. 14, 1941 (Aug. 26, 1938).

Fused quartz of porcelain-like appearance. SIZUKA NUMAKURA, YOHBI YAMAGUTI, HAYATA SIGENO, AND KUZI SABGUSA (Toden Denkyu Co.). Japan. 129,017, Feb. 27, 1939; *Chem. Abs.*, **34**, 8201 (1940).—Fused quartz is ground, molded, and heated above 1000° to make a porcelain-like product.

Glass block and wall assembly. E. J. WINSHIP (Corning Glass Works). Can. 392,598, Nov. 19, 1940 (Dec. 23, 1938). G.M.H.

Glass composition. F. D. TILLYER, H. R. MOULTON, AND T. M. GUNN (American Optical Co.). U. S. 2,226,418, Dec. 24, 1940 (May 15, 1936; renewed May 10, 1940).—A vitreous composition resulting from the fusing together of HPO_3 81, Al_2O_3 7.5, $BaCO_3$ 4.5, and $Fe_3(PO_4)_3$·$8H_2O$ 1 to 10%.

Glass melting and delivering apparatus and method. B. H. KOOB (Hartford-Empire Co.). U. S. 2,226,498, Dec. 24, 1940 (Aug. 27, 1938).

Glass-to-metal seals. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 529,593, Dec. 4, 1940 (May 21, 1938).

Glass structure. MILOS POLIVKA. U. S. 2,227,842, Jan. 7, 1941 (Dec. 22, 1938).—A glass wall composed of individual glass blocks recessed in each of their circumferential surfaces and multiarmed anchoring elements.

Glassware forming and finishing machine. ROBERT G. MCLEISH (O'Neill European Machine Co.). Can. 392,219, Oct. 29, 1940 (July 6, 1937). G.M.H.

Glass wool packing. A. D. SABORSKY (Fiberglas Canada, Ltd.). Can. 392,320, Nov. 5, 1940 (March 11, 1938; in U. S. March 13, 1937). G.M.H.

Glaze for decorating glassware. A. J. DEYRUP (E. I. du Pont de Nemours & Co.). U. S. 2,225,161, Dec. 17, 1940 (March 23, 1937).—A low-melting glaze for decorating glassware consists principally of lead silicate which possesses the following composition: lead oxide 55 to 80, silica 15 to 35, and titanium dioxide 2 to 7%, the percentages being by weight based on the total weight of the glaze.

Heating furnace for tempering glass. GLACERIES RÉUNIES (SOC. ANON.). Fr. 853,159 and 853,160, April 15, 1939. D.A.B.

Hollow glass articles. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Brit. 529,354, Dec. 4, 1940 (June 3, 1938).

Hydraulic machine for molding glass articles. J. P. BENOIT, C. C. KINKER, R. G. ALLEN, H. A. ROHRICH, AND C. W. SCHREIBER (Owens-Illinois Glass Co.). U. S. 2,225,898, Dec. 24, 1940 (Jan. 14, 1937). J. B. HAWLEY, JR., IRVING NELSON, D. F. HALLBERG, AND EARL CANNON (Owens-Illinois Glass Co.). U. S. 2,225,631, Dec. 24, 1940 (Jan. 14, 1937).

Intermittent driving gear for glassforming machines. W. B. MITCHELL. Brit. 529,184, Nov. 27, 1940 (May 24, 1939).

Joining pieces of earthenware with glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 846,309, May 14, 1938. D.A.B.

Lens-surfacing machine. R. F. DUFFENS. U. S. 2,225,826, Dec. 24, 1940 (Jan. 29, 1940).

Machine for the continuous manufacture of a ground and polished band of glass. PILKINGTON BROS., LTD. Fr. 852,414, March 31, 1939. D.A.B.

Machine for forming glass articles. L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 2,228,613, Jan. 14, 1941 (April 5, 1937).

Machine for molding glass articles. J. P. BENOIT, C. C. KINKER, R. G. ALLEN, H. A. ROHRICH, AND C. W. SCHREIBER (Owens-Illinois Glass Co.). U. S. 2,225,899, Dec. 24, 1940 (April 15, 1937).

Machine for working glass. CORNING GLASS WORKS. Fr. 851,484, March 11, 1939. D.A.B.

Machine for working glass tubes. J. DICHTER. Fr. 850,619, Feb. 20, 1939. D.A.B.

Making glass-to-metal seals. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 529,283, Nov. 27, 1940 (May 28, 1938).

Manufacture of glass tubes. R. H. KOENIG (Kimble Glass Co.). U. S. 2,228,010, Jan. 7, 1941 (March 29, 1938).

Manufacture of sheets or boards containing mineral wool. A. L. CLAPP. U. S. 2,225,100, Dec. 17, 1940 (May 9, 1938).

Means for drawing sheet glass, especially with Fourcault machines. DEUTSCHE TAFELGLAS AKT.-GES. (Detag). Brit. 529,221, Nov. 27, 1940 (June 13, 1938).

Method and apparatus for producing glassware. R. J. BEATTY (Federal Glass Co.). U. S. 2,225,948, Dec. 24, 1940 (Jan. 28, 1938).

Method and means for forming glassware. EDWARD DANNER. U. S. 2,225,369, Dec. 17, 1940 (Aug. 11, 1936).—The method of conditioning molten glass for forming

glassware includes flowing the glass over wire parts, each of the wire parts spaced from the contiguous wire parts by distances greater than the diameters of the wire parts, intermixing portions of the glass as the glass moves over the wire parts, and progressively withdrawing the glass from the wire parts to form the ware.

Mineral wool board manufacture. ALBERT L. CLAPP (D.C.R., Ltd.). Can. 392,761, Nov. 26, 1940 (July 11, 1938; in U. S. May 9, 1938). G.M.H.

Mineral wool sheet manufacture. ALBERT L. CLAPP (D.C.R., Ltd.). Can. 392,760, Nov. 26, 1940 (July 11, 1938; in U. S. Jan. 19, 1938). G.M.H.

Obtaining a decorating effect resembling etched glass. P. RIBOUD AND J. J. ROSSET. Fr. 853,014, Oct. 29, 1938. D.A.B.

Opaque white glaze for decorating glassware. A. J. DEYRUP (E. I. du Pont de Nemours & Co.). U. S. 2,225,160, Dec. 17, 1940 (March 17, 1937).—A glaze for decorating glassware maturing below about 1200°F. comprises a mechanical mixture of finely divided titanium dioxide with a frit which is substantially lead borosilicate, the frit containing, in addition to lead oxide, silica, and boric oxide, a fluoride selected from the group which consists of the fluorides of sodium, potassium, lithium, and ammonium.

Phosphate glass. HANS GRIMM AND PAUL HUPPERT (W. H. Duisberg). U. S. 2,227,082, Dec. 31, 1940 (June 14, 1938).—Phosphate glass with a low softening point containing 34 to 44 P_2O_5, 20 to 80 Al_2O_3, less than 12 B_2O_3, and at least 25% of alkali, the content of Na_2O amounting to 8 to 21% and the content of K_2O amounting to 5 to 21%.

Preparing a complex glass. I. G. FARBENIND. A.-G. Fr. 853,105, April 14, 1939. D.A.B.

Press for the manufacture of multilayer nonsplintering glass. ADOLF KÄMPFER. U. S. 2,225,870, Dec. 24, 1940 (April 23, 1936).

Process and apparatus for melting glass. J. L. DRAKE (Libbey-Owens-Ford Glass Co.). U. S. 2,228,347, Jan. 14, 1941 (June 2, 1938).

Process for the tight union of metallic material to ceramic objects. SOC. ANON. DES ATELIERS DE SÉCHERON. Fr. 850,831, Feb. 24, 1939. D.A.B.

Producing objects having an increased mechanical resistance. CORNING GLASS WORKS. Fr. 851,329, March 8, 1939. D.A.B.

Production of fiber glass. H. K. MARTIN (Owens-Corning Fiberglas Corp.). U. S. 2,227,357, Dec. 31, 1940 (Oct. 21, 1937).

Safety device for glass-blowing machines. J. P. BENOIT, L. H. WIDEMAN, AND C. C. KINKER (Owens-Illinois Glass Co.). U. S. 2,227,374, Dec. 31, 1940 (April 28, 1938).

Sunglasses. ROSE EHRLICH. U. S. 2,225,625, Dec. 24, 1940 (Oct. 9, 1939).

Supplying a fused charge of glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST. GOBAIN, CHAUNY & CIREY. Fr. 850,846, Feb. 25, 1939. D.A.B.

System for the pouring of molten glass in fine streams of various diameters. VETROCOKE. Fr. 851,602, March 15, 1939. D.A.B.

Thermically insulating glasses and glazes. J. CARLIER. Fr. 843,910, Sept. 26, 1938. D.A.B.

Uniting glass to glass and metals to glass. J. J. HOPFIELD (Libbey-Owens-Ford Glass Co.). U. S. 2,228,352, Jan. 14, 1941 (Sept. 15, 1939).

Vitrifiable enamel. A. J. DEYRUP (E. I. du Pont de Nemours & Co.). U. S. 2,225,162, Dec. 17, 1940 (Feb. 28, 1938; renewed Sept. 13, 1939).—A sulfide-resistant, low-melting, vitrifiable enamel suitable for decorating glassware containing, as melted-in ingredients thereof, titanium dioxide and lithium oxide.

Structural Clay Products

Acceptance test project. F. H. JACKSON. *Proc. Nat. Paving Brick Assn.*, **1939**, pp. 78–81.—A progress report on the program of tests is given. **Discussion.** F. E. SWINEFORD. *Ibid.*, pp. 82–86. P.S.D.

Annual report of Research Bureau of National Paving Brick Assn., 1939. H. Z. SCHOFIELD. *Proc. Nat. Paving Brick Assn.*, **1939**, pp. 87–97.—S. discusses studies on separating agents and fillers. **Report for 1940.** *Ibid.*, **1940**, pp. 2–7.—A progress report is given on (1) the study of new separating agents, (2) new nonexuding fillers, and (3) the acceptance test investigation. P.S.D.

Baltimore, Maryland, brick pavements. W. H. CULLIMORE. *Proc. Nat. Paving Brick Assn.*, **1939**, pp. 25–30.—Construction methods are described. P.S.D.

Brick cavity walls. ANON. *Architectural Forum*, **73** [6] 527–30 (1940).—Cavity walls are new in America although they have been used extensively in England where the climate is damp and where their advantages have been established in actual practice. Designed to produce a watertight load-bearing exterior wall which can be plastered directly without furring, thus reducing the cost, they have further advantages of insulation, quick drying, freedom from efflorescence, tighter aperture connection, and sleekness due to absence of usual header courses. Cavity walls are distinguished from all other forms of hollow masonry by a continuous, vertical, and horizontal air space bridged by no masonry ties. Z bars 1/4 in. in diameter (galvanized or rust resistant) are placed as ties between the inner and outer leaves of the wall every sixth mortar course and 3 ft. on center horizontally. The type of wall varies according to the load, but the variation is made in the inner leaf. The outside leaf is 4 in. thick, the air space is 2 in. thick, and the inner leaf is either 2 in. thick (brick on edge) for light nonbearing walls, 4 in. thick (brick laid flat) for ordinary load, or 8 in. thick with regular header ties for heavy construction. U. S. Bureau of Standards tests show the strength of this type of wall to be practically equal to that of the solid type. Dampproofing and workmanship depend on the cavity which must be free from collected moisture entering from the outside leaf and free from mortar drippings. The only additional cost, which is negligible, is for the wire ties; the labor requirement for a 10 in. cavity wall is the same as that for an 8 in. solid wall. As cavity walls are plastered directly, there is a substantial saving over solid brickwork plus lath and furring. Illustrated. See "Cavity. . .," *Ceram. Abs.*, **20** [1] 16 (1941). M.E.P.

Brick pavement experience in Pittsburgh. J. J. CROAK. *Proc. Nat. Paving Brick Assn.*, **1940**, pp. 21–30.—Observations on various projects of the city are given. P.S.D.

Brick pavement improvements. MARK CHAMBERS. *Proc. Nat. Paving Brick Assn.*, **1939**, pp. 7–14; see *Ceram. Abs.*, **19** [2] 46 (1940). P.S.D.

Brick pavements in St. Petersburg, Florida. F. O. LEE. *Proc. Nat. Paving Brick Assn.*, **1940**, pp. 45–50.—The adaptation of brick pavements to local conditions is discussed. P.S.D.

Brick paving experience in Borough of Queens, New York City. A. K. JOHNSON. *Proc. Nat. Paving Brick Assn.*, **1940**, pp. 31–43; abstracted in *Dependable Highways*, No. 167, pp. 4–7 (1940). P.S.D.

Brick paving for foundry floor. H. A. MASON. *Proc. Nat. Paving Brick Assn.*, **1939**, pp. 31–35; see *Ceram. Abs.*, **18** [10] 269 (1939). P.S.D.

Brick relaying in Dayton, Ohio. J. F. HALE. *Proc. Nat. Paving Brick Assn.*, **1939**, pp. 65–70. **Discussion.** F. O. ANDEREGG. *Ibid.*, p. 71. See *Ceram. Abs.*, **19** [2] 46 (1940). P.S.D.

Construction of brick storm drain in Ashtabula, Ohio. F. A. COLLINS. *Proc. Nat. Paving Brick Assn.*, **1940**, pp. 64–71; see *Ceram. Abs.*, **19** [10] 235 (1940). P.S.D.

Effect of efflorescence on brick and masonry. H. SEIPP. *Bautenschutz*, **9**, 113–19 (1938); *Chem. Zentr.*, **1939**, I,

765; *Chem. Abs.*, **34**, 6783 (1940).—The possibility of the action of osmotic pressure is discussed. Flaws already present are made larger by efflorescence. Chemical attack takes place under the influence of efflorescence. Mechanical attack follows. The formation of extensive encrustation and the action of frost must be considered. The damaging effects of algae, lichens, moss, etc., are discussed.

Manufacture of silicate brick from the alluvial sand of the Dnieper. A. A. AVERKIN AND S. M. TSAREV. *Stroitel. Materialy*, **1938**, No. 2, pp. 23–26; *Chem. Zentr.*, **1939**, I, 2847; *Chem. Abs.*, **34**, 7557 (1940).—Laboratory and plant experiments are reported on the production of sand-lime brick from the sand taken from the bed of the Dnieper. The sand is washed and the water is drained off. The sand contains 94.71% SiO_2, 2.83% $Na_2O + K_2O$, and slight amounts of clayey impurities. CaO (6.5 to 8.5%) is added, and the brick are pressed by the usual method, steamed under 8 atm. pressure, and dried for 20 days.

Minneapolis brick pavement maintenance. H. A. WHITE. *Proc. Nat. Paving Brick Assn.*, **1940**, pp. 51–57; see *Ceram. Abs.*, **19** [6] 139 (1940). P.S.D.

Reinforced brick pavement test project. F. C. HIGLEY. *Proc. Nat. Paving Brick Assn.*, **1939**, pp. 54–58.—Construction details of a 200 ft. x 20 ft. 8 in. experimental road section are given. **Discussion.** E. V. POSTON ET AL. *Ibid.*, pp. 58–64. See "Recent . . .," *Ceram. Abs.*, **20** [2] 44 (1941). P.S.D.

Springfield, Illinois, brick pavements. M. P. O'BRIEN. *Proc. Nat. Paving Brick Assn.*, **1939**, pp. 15–24.—Bedding courses and fillers are discussed. P.S.D.

Vibrated monolithic brick pavement. L. L. LUKE. *Proc. Nat. Paving Brick Assn.*, **1939**, pp. 37–47.—The advantages of vibratory construction are discussed. L. describes the construction details including (1) subgrade, (2) concrete base, (3) vibrated brick surface, (4) grouting operation, and (5) expansion joint provisions. P.S.D.

Vibrated monolithic pavement. W. L. BARR. *Proc. Nat. Paving Brick Assn.*, **1939**, pp. 48–54.—Old monolithic vs. new monolithic construction is discussed. P.S.D.

PATENTS

Brick. P. ALBERGE. Fr. 50,191, Jan. 27, 1939; addition to Fr. 792,286. J. SCHWARTZBART, W. FEITH, AND J. FISCHER. Fr. 853,599, April 28, 1939. D.A.B.

Building brick. W. FEITH, J. SCHWARTZBART, AND J. FISCHER. Brit. 529,105, Nov. 27, 1940 (May 12, 1939).

Means for manufacturing brick, etc. F. J. CANNON. U. S. 2,226,966, Dec. 31, 1940 (March 11, 1939).—Means for manufacturing brick, etc., comprising a portable body having a vertically movable bottom, means for forcing the bottom upwardly, the body being adapted to contain the material to be formed into brick, etc., a frame, means for raising and lowering the frame, the frame when lowered being adapted to rest upon the portable body, releasable means for locking the frame to the body, the frame being divided into a plurality of molding chambers, the upward movement of the bottom of the portable body lifting the material within the body and compressing it within the molding chambers of the frame.

Refractories

Action of alkalis on refractory materials: VI, Action of vapor from a potash-silica glass on refractory materials at 1200°C. F. H. CLEWS, H. M. RICHARDSON, A. CHADEYRON, AND A. T. GREEN. *Bull. Brit. Refrac. Research Assn.*, No. 41, p. 33 (Sept., 1936); reprinted in *Trans. Brit. Ceram. Soc.*, **39** [10] 289–96 (1940); see *Ceram. Abs.*, **16** [5] 150 (1937). **VII, Aspects of the action of alkali chloride vapors on refractory materials at 1000°C.** F. H. CLEWS, H. M. RICHARDSON, AND A. T. GREEN. *Bull. Brit. Refrac. Research Assn.*, No. 44, p. 38 (Oct., 1937); reprinted in *Trans. Brit. Ceram. Soc.*, **39** [10] 297–303 (1940); see *Ceram. Abs.*, **17** [2] 69 (1938). **VIII, Experiments on the action of the vapor from sodium aluminate and sodium carbonate at various temperatures.** F. H. CLEWS, H. M. RICHARDSON, AND A. T. GREEN. *Bull. Brit. Refrac. Research Assn.*, No. 44, p. 45 (Oct., 1937); reprinted in *Trans. Brit. Ceram. Soc.*, **39** [10] 304–11 (1940); see *Ceram. Abs.*, **17** [2] 69 (1938). For Parts **XII** and **XIII** see *ibid.*, **20** [2] 45 (1941). R.A.H.

Analyzing chrome ore and chrome-ore refractory products. ALBERT J. BOYLE, DONALD F. MUSSER, AND OWEN S. KEIM. *Bull. Amer. Ceram. Soc.*, **20** [1] 7–9 (1941).

Causes of excessive wear of linings of shafts of blast furnaces and methods of increasing their resistance. N. STRAUS. *Stal*, **1938**, No. 5, pp. 10–15.—The principal causes of excessive wear are (1) irregular distribution of the charge, (2) incorrect choice of the depth of the filling, (3) unsatisfactory quality of the brickwork of the lining and unsatisfactory composition of the solution used to fill the joints, and (4) incorrect use of the furnace. To increase the resistance of the lining of the shafts of blast furnaces it is necessary to (1) establish the optimum sizes of the coke charge, the method of filling the raw materials, and the depth of the filling; (2) verify the work of the filling apparatus in respect to disposition of the filling comb and the work of Mac-Kee apparatus; (3) cool the lower and upper parts of the shafts; (4) pay more attention to the control of preparation of raw materials; and (5) establish an efficient control of water used to moisten the raw materials. B.E.K.

Effect upon furnace refractories of protective gases for high-carbon steels. JOHN H. LOUX. *Ind. Eng. Chem.*, **33** [1] 42–46 (1941).—Protective atmosphere gas for high-carbon steels presents the same firebrick disintegration problem to heat-treating furnace engineers that is found in the blast furnace. Blast-furnace operators solved their problem years ago by using a dense-surface brick which is fired in a reducing atmosphere. Extensive tests were run on a recent installation of hood-type furnaces for annealing high-carbon steels to prove that what was occurring in the blast furnace could occur in exactly the same manner in a heat-treating furnace. A nondisintegrating type of firebrick was used in the hood-type furnace bases; among its advantages over lightweight brick were its resistance to abrasion and its heat-storage capacity. Recent work has shown that the reducing firing period must continue to a point beyond which all iron oxides in the brick are changed to the magnetic type. This chemical change is reversible, and it is necessary to continue the reducing fire until all iron is absorbed into a silicate glass. Illustrated. F.G.H.

Effect of hydrocarbon gases on refractory materials: IV, Effect of ethylene. E. ROWDEN. *Bull. Brit. Refrac. Research Assn.*, No. 44 (Oct., 1937); reprinted in *Trans. Brit. Ceram. Soc.*, **39** [9] 266–68 (1940); see *Ceram. Abs.*, **17** [2] 71 (1938); **20** [2] 45 (1941). R.A.H.

Furnace walls. ANON. *Power Plant Eng.*, **44** [10] 109 (1940).—An illustrated description is given of a sectionally supported all-brick furnace wall construction, for either solid or air-cooled walls, involving a new principle of design. Construction provides for expansion joints to relieve both vertical and horizontal expansion. These expansion joints divide the inner wall into small rectangular self-supporting panels without the use of expensive supporting steelwork. B.C.R.

Material for crucibles of high-frequency furnaces. V. MAKHINOV. *Novosti Tekhniki*, **1939**, No. 2–3, p. 22.—Special crucibles were prepared from 56 ground quartz, 20 marshalite, 12 ground glass, and 12% white refractory clay. The life of these crucibles is about 200 fusions. The new crucibles are used to fuse very refractory alloys such as Monel metal, manganese alloys, and lead bronze containing about 21% of lead. Use of these crucibles may result in an increase in production of the high-fre-

quency furnace and a saving in material, labor, and electricity. B.E.K.

Refractory cement containing barium aluminate. R. MATVEEV. *Novosti Tekhniki*, **1939**, No. 23–24, pp. 33–34.—The Institute of Refractories (Leningrad) has developed three methods of preparing cements containing barium aluminate: (1) Alumina or bauxite is fired with various barium salts such as barium carbonate or sulfate (barytes). (2) By sintering bauxite with soda and lixiviating, a solution of sodium aluminate is obtained; when the solution is mixed with a solution of any barium salt and treated with CO_2, a mixture of aluminates and barytes is precipitated. The precipitate is washed, dried, calcined, and ground. (3) By sintering bauxite with barytes and additions of coal, coke, and limestone and then lixiviating, a solution of barium aluminate is obtained which is decomposed by CO_2. The compressive strength of the cement obtained by sintering the mixture of alumina with barium carbonate after 24 hr. in water is 383 kgm. per cm.^{2}; the cement obtained by calcining a charge of Tikhvin bauxite possesses a compressive strength of 254 kgm. per cm.^{2}. See "Use . . .," *Ceram. Abs.*, **18** [3] 77 (1939). B.E.K.

Refractory disintegration by carbon monoxide. K. C. CARNES. *Glass Ind.*, **21** [12] 522, 535 (1940).—The reaction between refractory material and CO at about 500°C. which leads to the disintegration of firebrick is well known, but the results are sometimes confusing. Findings of researches in this field by Osann, O'Hara and Darby, Phelps, Westman, and Ruprecht, Pierce, and Harvey are summarized. To prevent disintegration, firebrick should be made from naturally pure or iron-freed clays. Firing in a reducing atmosphere, thus converting the ferric oxide present into ferrous oxide, also lessens the danger of disintegration. A.P.

Refractory materials from Norwegian raw materials. V. M. GOLDSCHMIDT. *Tek. Ukeblad*, **87**, 1–7 (1940); *Chem. Abs.*, **34**, 6031 (1940).—G. gives a summary of the thermal and mechanical properties of refractory materials such as chamotte, silica, magnesite, forsterite, chromite, and chrome magnesite. The possibility of producing some of them from Norwegian raw materials is discussed.

Solid solutions of magnesium aluminum spinel + chromite. V. V. GONCHAROV AND A. T. KLEĬNBERG. *Zapiski Vserossiĭskogo Mineral. Obshchestva*, **68** [2] 199–202 (1939); *Khim. Referat. Zhur.*, **1939**, No. 12, pp. 18–19; *Chem. Abs.*, **34**, 8196 (1940).—Confirmation of the supposition that proper treatment of the mixtures Mg Al spinel + chromite must lead to the formation of solid solutions would facilitate the production of monolithic refractories from these components. Spinel prepared from a mixture of magnesite and technical alumina in various ratios (95, 90, 75, 65, 50, 25, and 10% of spinel) was heated with chromite for 2 hr. at 1600°. Microscopic and X-ray examinations showed that the mixtures form a continuous series of solid solutions.

Standardization of the quality of silica brick. STANISLAW GOLCZEWSKI. *Hutnik*, **10**, 474–80 (1938); *Chem. Zentr.*, **1939, I**, 1229; *Chem. Abs.*, **34**, 7078 (1940).—New standards are suggested which omit density and composition but introduce linear thermal expansion, volume expansion at high temperatures, and resistance to temperature changes.

Structural design of refractory concrete. R. T. GILES. *Ind. Heating*, **7** [10] 976–86; [11] 1106–13; [12] 1211–12 (1940).—Curves of compressive strength and flexural strength are given for mixtures of 1 bag of calcium aluminate cement and 4 bags of insulating aggregate; for slabs with an ultimate strength of 1000 lb. per sq. in. or less, the curves are rather flat between 0° and 2000°; for slabs with a strength of over 2000 lb. per sq. in., the curves drop more or less steeply with increasing temperature to about 1500° to 1600°, increase a little up to about 2100°, and then drop rapidly to 0 at 2400°F. G. describes the design of the walls, taking into account linear shrinkage and volume changes, application to high-temperature furnaces, and methods of reinforcing. Maintenance and repair methods are discussed. Even in low-temperature furnaces, insulating concrete can be employed at reasonable cost because insulating grog is much cheaper per pound in aggregate form than in brick form. Refractory concrete can be reinforced in such a manner that practically no size limitations exist. In a concrete wall 80% of the thickness of a brick wall, about the same heat loss will result; there is much less heat storage in the concrete on account of its greater porosity (about 15% greater than that of the brick). The weight of a concrete wall is therefore only about 67% of that of the brick wall. M.H.

PATENTS

Bonded refractory. F. E. LATHE, LISLE HODNETT, AND N. P. PITT. Can. 392,844, Dec. 3, 1940 (April 6, 1938). G.M.H.

Dry process for manufacturing refractory brick containing dolomite or lime. SOC. ANON. DES HAUTS-FOURNEAUX DE LA CHIERS. Fr. 853,889, Nov. 22, 1938. D.A.B.

Furnace-wall construction. HOWARD HICKS (Thermo Fire Brick Co.). U. S. 2,225,216, Dec. 17, 1940 (April 15, 1939).

Furnace walls of water-tube boilers. BENNIS COMBUSTION, LTD., AND A. W. BENNIS. Brit. 529,414, Dec. 4, 1940 (May 31, 1939).

Magnesia brick. YOSIKAZU YAMAMOTO. Japan. 129,-113, March 4, 1939; *Chem. Abs.*, **34**, 8201 (1940).—Brick from MgO clinker is dried and coated with a mixture of Fe_2O_3 and a small amount of feldspar and is then calcined moderately. This process prevents cracking and absorption of moisture.

Manufacturing a refractory material from magnesia. G. SOZZETTI. Fr. 847,389, Dec. 12, 1938. D.A.B.

Material high in alumina content. T. GOLDSCHMIDT (Vereinigte Aluminumwerke A.-G.). Fr. 845,529, Nov. 2, 1938. D.A.B.

Pots for molten metal, slag, etc. MACKINTOSH-HEMPHILL CO. Brit. 529,146, Nov. 27, 1940 (Aug. 23, 1938).

Producing pulverized refractory cements and derived products. I. G. FARBENIND. A.-G. Fr. 853,675, May 1, 1939. D.A.B.

Refractory anchor. G. F. DOYLE. U. S. 2,225,983, Dec. 24, 1940 (Aug. 22, 1938).

Refractory article and wall. R. C. BENNER AND J. C. MCMULLEN (Carborundum Co.). U. S. 2,226,701, Dec. 31, 1940 (Dec. 19, 1935).—A furnace wall for contact with a bath of molten flux, the wall being composed at least in part of long, relatively narrow refractory castings adjoining one another, the castings being composed of a cast alumina refractory material in which the individual alumina crystals are smaller than 0.25 mm. in diameter, and the castings being so positioned that the long axes of the castings are vertical and the narrow faces of the castings are in contact with the molten bath.

Refractory bodies for gas fires. RADIATION, LTD., AND A. R. BENNETT. Brit. 529,085, Nov. 27, 1940 (May 22, 1939).

Refractory product. Y. J. SEURAT. Fr. 852,899, April 11, 1939. D.A.B.

Refractory product from dolomite and chromite. SOC. ANON. DES ÉTABLISSEMENTS A. VALUY. Fr. 852,198, Oct. 5, 1938. D.A.B.

Refractory products and electrical insulating products. SOC. GÉNÉRALE DE CONSTRUCTIONS ÉLECTRIQUES & MÉCANIQUES (Als. Thom). Fr. 852,690, Oct. 19, 1938. D.A.B.

Terra Cotta

Principles for the manufacture and testing of ceramic radiators for central heating systems. REICHARBEITSGEMEINSCHAFT FÜR WÄRMEWIRTSCHAFT. *Gesundh.-Ing.*, **63** [15] 176 (1940).—Principles and regulations are given under the headings (1) description, (2) requirements, (3) testing rules, and (4) explanations. W.D.K.

Use of silicate protective coatings for chemical equipment. G. V. CHUCHKIN. *Prom. Org. Khim.*, **6**, 584–86 (1939); *Chem. Abs.*, **34**, 6489 (1940).—Satisfactory results are reported with the use of two special acid-resistant cements in lining chemical apparatus with tile. The cements (described by Stepichev) showed but little destruction after more than two years' use in contact with organic and inorganic acids, Na_2SO_3, $CuSO_4$, Cl, and other chemical agents.

PATENTS

Cellular insulating product. G. DESAGNAT. Fr. 850,027, Feb. 8, 1939. D.A.B.

Interlocking roofing tile. RICHARD HEDRICH, SR. (A. P. Myers). U. S. 2,226,560, Dec. 31, 1940 (March 31, 1939).

Roofing tile. E. KUHL. Fr. 834,972, March 8, 1938. D.A.B.

Tile. L. LUDOWICI. Fr. 850,624, Feb. 20, 1939. D.A.B.

Whiteware

Centenary anniversary of Harker Pottery Co. LUCILLE T. COX. *East Liverpool Rev.*, Jan. 5, 1940; *Bull. Amer. Ceram. Soc.*, **20** [1] 25–27 (1941).

Effect of temperature on the surface and mass resistance of a dielectric. E. MARYSSAEL. *Electricité*, **22**, 372–74 (1938); *Chem. Zentr.*, **1939, I**, 1141–42; *Chem. Abs.*, **34**, 6865 (1940).—The mass and surface resistances of glass and porcelain were measured by use of a d.-c. voltage of 1000 volts. The mass resistance was found to decrease with increasing temperature, although the surface resistance at first increased with increasing temperature, passed through a maximum at about 30°, and then decreased again. This is explained by the fact that in reality it is not purely the surface resistance that is measured but rather a resistance made up of the two parallel resistances, the surface resistance and the mass resistance encountered by that portion of the current entering the material. The first of these depends in a large measure on the moisture and decreases with increasing temperature, whereas the second increases as the temperature increases. The second is also a function of the surface of contact of the electrodes and the thickness of the dielectric.

Electric strength of some solid dielectrics. A. E. W. AUSTEN AND S. WHITEHEAD. *Proc. Roy. Soc.* [London], **A176** [964] 33–50 (1940).—Methods are described by which the "intrinsic" electric strength of solid dielectrics may be defined and evaluated. The magnitudes of and the effect of temperature and thickness upon the electric strengths of mica, quartz, potassium bromide, and other alkali halides agree with Fröhlich's theory of electronic breakdown. Fused quartz has a relatively higher electric strength than crystalline quartz. Experiments on mica indicate that the strength is not sensitive to its microstructure. A.P.

Electrical conduction and related phenomena in solid dielectrics. MILLARD F. MANNING AND MAURICE E. BELL. *Rev. Modern Phys.*, **12**, 215–56 (1940); *Chem. Abs.*, **34**, 6865 (1940).—A review is given. 176 references.

Improvements on and experiences with frostproof lavatories. PAUL MENSING. *Gesundh.-Ing.*, **63** [10] 116–17 (1940).—The proper construction of frostproof lavatories is described, and recent developments in this field are given. W.D.K.

Physical effects of glazes: I, Effect of glaze on the mechanical strength of electrical porcelain. C. BETTANY AND H. W. WEBB. *Trans. Brit. Ceram. Soc.*, **39** [10] 312–35 (1940).—The effect of a glaze in increasing or decreasing the modulus of rupture of a biscuit rod is determined mainly by the difference in the expansion coefficients of body and glaze, but it is not quantitatively proportional to this difference, tending to reach a constant value when the difference exceeds a critical amount. It is directly related to the crazing resistance of the glazed ware as measured by the autoclave test. A crazeable glaze may reduce the value of the modulus of rupture to less than half that of the unglazed ware. The effect of the glaze on modulus of rupture is exactly opposite to its effect on crushing strength. The modulus of rupture of a body may be greatly increased by grinding, but the ultimate glazed strength may be less than normal if the usual glaze is used. A range of values is certain to be obtained from tests of modulus of rupture specimens prepared under supposedly identical conditions. The range of variation is dependent on the surface finish of the body, being less for glazed ware than for biscuit ware and less for vitreous ware than for porous ware. The shape and the thickness of the test specimen also have an effect on the result. The general results of modulus of rupture and tensile tests on ceramic bodies can be explained by a hypothesis of the presence of minute surface cracks. R.A.H.

Talc spark-plug insulators. A. M. AKHYAN. *Prom. Stroitel. Materialov*, **2** [7] 49–54 (1940).—$MgSiO_3$ (as clinoenstatite) and mullite crystallize from the glass. An addition of corundum dust increases the deformation temperature and solidifies the crystalline skeleton of the ware. P.B. & E.S.

Thermal and moisture expansion of kaolins and bodies fired to different temperatures. H. THIEMECKE. *Jour. Amer. Ceram. Soc.*, **24** [2] 69–75 (1941).—9 figures, 5 tables, 9 references.

Whiteware glazes: II, Action of tin oxide and cerium oxide as opacifying agents. W. STEGER. *Ber. Deut. Keram. Ges.*, **20** [7] 310–18 (1939).—Twenty-two whiteware glazes were tested for various properties, e.g., fusibility, heat coefficient, etc. Further experiments were made with these glazes to find which glaze would give the best opacification using the smallest amount of opacifier, and the influence of tin oxide and cerium oxide on opacification was observed. In enamel and faience glazes boric acid is seldom used. The boric acid content in fritted opaque lead- and boric acid-containing whiteware glazes with tin oxide as opacifier is kept very low. Glazes develop during the firing period because of the higher content of tin oxide. They do not precipitate while cooling if the boric acid content is high. To retain the opacifying property of the tin oxide in lead- and boric acid-containing glazes, the alkalis necessary for fusion should be added totally or partially as potash, and potash (K_2O) should be substituted for soda (Na_2O). The opacifying power of cerium oxide is 2.5 to 3 times larger than that of tin oxide. Cerium oxide is obtained from monazite sand. S. describes the method of introducing the opacifier into the glazes and the firing of the ware. Results obtained in regard to the color, coverage, surface development, gloss, and special properties are stated. The glazes are classified according to color, coverage, flowability, and appearance. Both tin oxide and cerium oxide develop a very good mat glaze. A good mat glaze opacified with tin oxide has the following chemical analysis: K_2O 4.8, Na_2O 2.6, CaO 6.2, PbO 21.0, Al_2O_3 14.3, SiO_2 46.5, and B_2O_3 4.6. Its milling formula is as follows: feldspar 30.8, crystalline borax 13.6, calcite 12.0, red lead 23.7, soda 1.0, and sand 18.9; mill addition, 28.8 parts raw Zettlitz kaolin to 100 weighed parts of frit. The results of the experiments are critically discussed. The influence of the four most important glaze formers, lead oxide, aluminum oxide, silicic acid, and boric acid, on the opacifing power of tin oxide is examined. The influence of the chemical composition of lead- and boric acid-containing glazes on the opacifying property of tin oxide is given in a table. For Part I see "Comparative. . .," *Ceram. Abs.*, **16** [1] 27 (1937). W.D.K.

PATENTS

Bushing. L. B. CHUBBUCK (Westinghouse Electric & Mfg. Co.). U. S. 2,228,440, Jan. 14, 1941 (Oct. 26, 1939).

Ceramic insulators. PORZELLANFABRIK KAHLA. Fr. 844,603, July 28, 1939; *Chem. Abs.*, **34**, 7561 (1940).—An

electric and dielectric insulator for condensers, particularly for high-frequency applications, is made from a ceramic mixture of BeO and TiO_2 of small dielectric loss.

Electric insulator. Champion Spark Plug Co. Fr. 851,399, March 9, 1939. D.A.B.

Design for paper holder equipped toilet bowl. David Vigo. U. S. 124,215, Dec. 24, 1940 (May 23, 1940).

Making spark plugs. L. W. G. Flynt (Breeze Corporations, Inc.). U. S. 2,225,105, Dec. 17, 1940 (June 10, 1937); original application June 12, 1935, now U. S. 2,083,916, June 15 ,1937.

Manufacture of ceramic products resistant to temperature changes. Robert Bosch G.m.b.H. Fr. 853,331, April 22, 1939. D.A.B.

Manufacturing ceramic or vitreous ware. A. O. Austin. U. S. 2,224,853, Dec. 17, 1940 (Oct. 26, 1939).—The method of manufacturing ceramic ware articles comprises the steps of forming an article with an internal recess and sealing the recess while the gas therein is at a pressure higher than atmospheric pressure.

Manufacturing clay pottery. Pittsburgh Glass Co. Fr. 850,783, Feb. 24, 1939. D.A.B.

Method and means for automatically feeding and forming plastic material in the manufacture of pottery. W. J. Miller. U. S. 21,672, Dec. 24, 1940 (March 26, 1937); reissue of original 1,769,528 (*Ceram. Abs.*, **9** [9] 755 (1930)).

Molded electric insulating article. Ernst Albers-Schönberg (Steatit-Magnesia A.-G.). U. S. 2,226,299, Dec. 24, 1940 (Sept. 21, 1934).—A ceramic dielectric of high dielectric constant and low dielectric loss consists of a dense fired mixture containing at least 30% titanium dioxide and the remainder containing clay substances.

Porcelains easily fused to glass. Saburo Isoya (Nippon Densi Kogyo Co.). Japan. 128,223, Jan. 10, 1939; *Chem. Abs.*, **34**, 8201 (1940).—To feldspar-base porcelain is added 3 to 10% TiO_2.

Spark plug. Thomas Dukelow. U. S. 2,226,711, Dec. 31, 1940 (Jan. 2, 1940). Fred Kapp. U. S. 2,226,414, Dec. 24, 1940 (Sept. 16, 1939). U. S. 2,226,415, Dec. 24, 1940 (Sept. 16, 1939; March 5, 1940).

Equipment and Apparatus

Accurate measurement of X-ray diffraction films. Harold P. Klug. *Ind. Eng. Chem., Anal. Ed.*, **12** [12] 753–54 (1940).—K. presents construction details for an instrument which is simple to manipulate, satisfactory for both powder and rotation photographs, and economical to construct, since it requires only standard available parts and simple machine work. Illustrated. F.G.H.

Alloys for high-temperature service. George F. Geiger. *Ind. Heating*, **7** [10] 948–55; [11] 1068–72, 1075; [12] 1174–78 (1940).—Resistance to corrosion and high mechanical properties are characteristic of Ni and the high Ni alloys. Four principal materials are used in wrought forms and as heating elements in enameling, glass, ceramic, and heat-treating industrial applications; their compositions are given in the following table:

	Ni (%)	Cu (%)	Fe (%)	Cr (%)	Al (%)
Monel	67.0	30.0	1.4		
Nickel	99.4	0.1	0.15		
D-Nickel	95.2	0.05	0.15		
Inconel	79.5	0.2	6.5	13.0	

	Si (%)	Mn (%)	C (%)	Melting point (°F.)
Monel	0.1	1.0	0.15	2370–2460
Nickel	0.05	0.2	0.1	2615–2635
D-Nickel	0.05	4.5	0.1	2645
Inconel	0.25	0.25	0.08	2540

Monel has useful properties up to about 1000°F. in sulfur-free oxidizing atmospheres. Ni can be used satisfactorily up to 1400° and higher in oxidizing atmospheres where the S content is below 0.5% and up to 2300° under not too high loads. The high Mn content of D-Ni gives it a better resistance to oxidizing sulfurous conditions at elevated temperatures, and it is used where the reducing atmosphere contains S-containing gases; its mechanical properties at high temperatures are somewhat higher than those of Ni. The Ni-Fe-Cr alloy, Inconel, is resistant to carburization, retains mechanical strength at high temperatures, is resistant to scaling, and is free from intergranular deterioration. In S-free oxidizing and reducing atmospheres, it can be used up to 2000° to 2100°F. A table shows its mechanical properties at various temperatures. Fittings, apparatus, glassmelting equipment, conveyer parts, and other examples of applications are described. M.H.

Apparatus and methods for measuring the mechanics of solid, liquid, and gaseous materials. Hermann Ebert. *Physik*, **8** [3] 81–96 (1940).—E. covers recent advances in the apparatus and methods used in the determination of elastic deformation, density, quantity, pressure, vacuum treatment, etc., of solid, liquid, and gaseous materials. 235 references. L.E.T.

Color characteristics of cement. L. R. Dawson, R. V. Andes, and T. D. Tiemann. *Ind. Eng. Chem.*, **33** [1] 95–98 (1941).—A quantitative method is based on measurements made with a Zeiss Pulfrich photometer. A bibliography is included. F.G.H.

Design of industrial exhaust systems. L. P. Hatch. *Ind. Eng. Chem.*, **33** [1] 111–13 (1941).—Illustrated. F.G.H.

Energy and flow charts for air calculations. W. R. New. *Combustion*, **11** [10] 33–36 (1940).—The accompanying charts, one for computing velocity and the other giving the ratio of flow per unit area as a function of pressure ratio, are based on the more exact but rather involved equation for velocity by de St. Venant and that for quantity of flow. By their use cumbersome calculations may be avoided in determining the velocity and the maximum quantity of air that will escape through a given orifice. Use of the charts, however, is not limited to the type of example given in the text. H.E.S.

Evaluation of X-ray reflection photographs. H. Neerfeld. *Mitt. Kaiser-Wilhelm Inst. Eisenforsch. Düsseldorf*, **22** [13] 213–16 (1940).—The evaluation of X-ray reflection photographs from the mechanical arrangement of the test, i.e., distance from film to specimen, centers of the interference circles of the comparison material, and the relations of the angles of incidence, is discussed in detail, and from it a new, more rapid determination of lattice constants is developed by projecting the exposures directly on a suitable nomogram paper. By this nomogram it is possible to read the lattice constants directly with only slightly less accuracy than by determining the values from direct evaluation of the photograph. A special slide rule for the evaluation by reflection X rays is described. M.H.

Hygrometer. Hans Siebert. *Gesundh.-Ing.*, **63** [9] 100–101 (1940).—A psychrometer is described. The dry-bulb and wet-bulb thermometers, the air mechanism, and the psychrometer tables are combined in one shell. The relative humidity can be read directly after adjusting two indicators. W.D.K.

Laboratory-size leaf-type pressure filter. T. F. Clark, N. Porges, and S. I. Aronovsky. *Ind. Eng. Chem., Anal. Ed.*, **12** [12] 755–57 (1940).—A laboratory-size, leaf-type pressure filter has been designed and constructed for experimental studies. Simple construction permits fabrication in the average laboratory shop. The filter leaves are adaptable to either top or bottom drainage. This filter has an effective filtering surface of 54 sq. in. and a calculated wet-cake capacity of 0.69 liter. Hydraulic pressures up to 30 lb. per sq. in. (gauge) have been used successfully. Illustrated. F.G.H.

Moistening clay with low-pressure vapor. M. I. Rogovol. *Prom. Stroitel. Materialov*, **2** [6] 45–49 (1940).—

The use of low-pressure vapor in the clay cutter is advantageous. P.B. & E.S.

Optics and electronics of solid and liquid materials. RUDOLF TOMASCHECK. *Physik*, 8 [2] 1–31 (1940).—T. reviews up-to-date discussions and literature on the adsorption and emission spectra, line spectra, diffusion and infrared spectra, luminescence, fluorescence, and phosphorescence of solid and liquid materials. 395 references. L.E.T.

Screened mercury-electrode clamps for dielectric measurements. E. RUSHTON AND E. J. PRATT. *Jour. Sci. Instruments*, 17 [10] 247–48 (1940).—Mercury-electrode clamps with a guard ring for the accurate determination of the dielectric constant and power factor of insulating materials in the form of disks about 5 cm. in diameter are described. The electrodes are made of mild steel, and fused silica insulation is used. The apparatus is suitable for measurements at frequencies up to 1 mc. per sec. as well as for d.-c. insulation measurements. 1 figure. J.L.G.

Transmission photometer. J. T. MIRELES MALPICA AND W. R. FANTNER. *Gen. Elec. Rev.*, 43 [9] 384–85 (1940).—A new photometer for measuring the density of spectral lines, possessing a high degree of compactness, mechanical simplicity, ease of operation, and flexibility, has been developed. Design features and characteristics are described. 3 illustrations. L.E.T.

PATENTS

Cleaning and foaming compositions. G. B. ELLIS (Sandoz, Ltd.). Brit. 529,040, Nov. 27, 1940 (May 3, 1939).

Equipment and process for the continuous manufacture of ceramic articles. A. DAL BORGO AND M. KORACH. Fr. 852,512, Oct. 10, 1938. D.A.B.

Hand cutting tool for the cutting off of thin flat plates made of clay. HEINRICH ZANGE. Ger. 688,443, Feb. 1, 1940 (Aug. 29, 1936); VI/80a. 36. D.A.B.

Machine for cutting tile. M. GENDRON. Fr. 832,279, Jan. 19, 1938. D.A.B.

Machine tool and method of controlling. R. V. BROMLEY (Hazel-Atlas Glass Co.). U. S. 2,225,409, Dec. 17, 1940 (Sept. 30, 1938).—A method of operating a lathe comprises rotating a work piece at a cutting speed, advancing a cutter at a feed rate along the surface of the work piece, shifting the cutter continuously during portions of each revolution of the work piece in a direction at an angle to the direction of the advance, and retaining the cutter at its point of maximum travel from the axis of the work piece for any given revolution thereof during intermediate portions of each revolution of the work piece.

Molding goods containing fire clay. B. J. MOORE. Brit. 529,043, Nov. 27, 1940 (May 8, 1939).

Kilns, Furnaces, Fuels, and Combustion

Annealing atmospheres from the combustion products of gaseous fuels. A. G. HOTCHKISS. *Ind. Eng. Chem.*, 33 [1] 32–38 (1941).—The history of the production of annealing-furnace atmospheres is given briefly. The applications of atmospheres of various compositions to the treatment of specific metals are discussed. Illustrated. F.G.H.

City gas for special atmospheres. CHALMER R. CLINE AND C. GEORGE SEGELER. *Ind. Eng. Chem.*, 33 [1] 46–54 (1941).—The authors present the composition and source of several typical protective furnace atmospheres produced from gases and used in such operations as metal annealing without scaling or decarburizing, bright hardening, clean heat treating, carburizing, fire protection, and purging of combustible gases from storage vessels. General methods followed and the equipment required in producing and purifying these special atmospheres are discussed. Original data are presented showing the effect on flue-gas composition of the amount of air supplied for combustion, fuel-gas composition, combustion chamber wall temperature, and flue-gas temperature when three fuel gases were burned with insufficient air for complete combustion. The composition of the flue products which will result when a fuel gas of given composition is burned with a predetermined air-gas ratio may be accurately estimated from the data presented. Minimum aerations supporting combustions of different fuel gases are indicated, and factors in furnace and burner design influencing combustion at low aerations are set forth. Illustrated. F.G.H.

Combustion calculations using the mol. H. L. NORRIS, JR. *Combustion*, 11 [9] 41–44 (1940).—In combustion calculations the use of the mol system is a time saver. It is explained and discussed with reference to the burning of coal, natural gas, and oil, and convenient charts applicable to these fuels are included. H.E.S.

Operation of chain-grate stokers. W. M. PARK. *Combustion*, 11 [10] 24–28 (1940).—P. reviews some of the fundamentals of chain-grate stoker operation to be considered when utilizing free-burning bituminous coals and lignite, including proper sizing of coal, range in draft for both natural and forced draft, coal distribution and segregation, addition of moisture, control of air supply, and overfire air. H.E.S.

Radiation of carbon dioxide and water vapor, particularly at high temperatures: I, Gaseous radiation on the basis of the Planck and Kirchhoff laws. HELLMUTH SCHWIEDESSEN. *Arch. Eisenhüttenwesen*, 14 [1] 9–14 (1940).—S. gives a highly theoretical treatment of the subject. 10 diagrams. **II, Interpretation of experimental data at high temperatures.** *Ibid.*, [4] 145–53.—On the basis of experimental evidence, it was established that the radiation of smoky, nonluminous gases is so much greater than that of luminous gases that with heavier layers of the former the effect of luminous radiation practically ceases. At the highest temperatures, such as in open-hearth furnaces, the radiation of carbon dioxide and water vapor does not increase to the extent that radiation of the luminous flame is substantially affected. These data were obtained from experiments conducted with carburated blast-furnace gas. **III, Evaluation of spectroscopic measurements.** *Ibid.*, [5] 207–10.—In spite of increasing absorption coefficient and band width, heat transfer number of band radiation increases from 0 to a maximum and then drops back again to zero. At high temperatures, short-wave bands do not produce any new maxima in total radiation values. J.D.G.

PATENT

Double deck continuous kiln. F. W. BROOKE (Swindell-Dressler Corp.). U. S. 2,224,895, Dec. 17, 1940 (Feb. 28, 1939).

Geology

Aggregate structure of clays. D. I. SIDERI. *Izvest. Akad. Nauk S.S.S.R., Ser. Geol.*, 1939, pp. 172–80.—A study of the composition of colloidal clay by means of X rays is possible only when the clay can be divided into its separate constituents. The iron oxides in the clay serve to cement the components together. By eliminating the iron oxides and separating the colloidal clay into its constituents, unknown minerals were detected in some clays. B.Z.K.

Application of geology to ore finding: II. H. E. EDWARDS. *Chem. Eng. & Mining Rev.*, 33 [385] 14 (1940).—E. describes methods applicable to the determination of faulted ore bodies. For Part I see *Ceram. Abs.*, 20 [1] 27 (1941). B.C.R.

Beryl. G. L. GARY. *Gemmologist*, 10, 34 (1940); *Chem. Abs.*, 34, 7786 (1940).—G. briefly describes beryl and gives a list of places where it occurs in California, including Riverside County (yellow, green, and blue crys-

tals), San Diego (crystals of all colors), Inyo (blue crystals), and Fresno and Tuolumne (unspecified).

Chemical disintegration of the silicates. CARL W. CORRENS. *Naturwissenschaften*, **28** [24] 369–76 (1940).—C. presents a theoretical investigation of ionization as the cause of the decomposition of natural silicates. The influence of pH, grain size, and temperature on the disintegration of the more common minerals is studied. Bibliography. J.M.N.

Chrome for Canada. J. W. CRAIG. *Trans. Can. Inst. Mining & Met.*, **43**, 762–80 (1940).—Canadian and world sources of chromium ore are described, and the uses of chromium are outlined. Since 1938 chrome brick has been made in Canada. Man-size lumps of imported ore are reduced in primary and secondary jaw crushers followed by rolls and screens. Fine-grinding is done in conical ball mills, with air classification. Grain sizing is rigidly controlled. The brick are fired in downdraft and tunnel kilns at temperatures between 2600° and 2900°F. Chrome brick are used in Canada chiefly for (1) bottoms, front and back walls, and uptakes of open-hearth furnaces, (2) soaking pits of steel mills, and (3) hearths of various steel reheating furnaces; they are also used between magnesite and silica brick in electric steel-melting furnaces, around the tapholes of copper reverberatory and nickel refining furnaces, and in kraft recovery smelters. In all these uses except the last two, chrome brick have been or are being largely replaced by Canadian-made chrome-bearing high-magnesia brick, which have outstanding advantages in spalling resistance, resistance to certain types of slag, and higher content of domestic raw materials. C. discusses chrome plastics and chrome cements. G.M.H.

Classification of some magnesian silicates and their alumina analogues. N. E. EFREMOV. *Compt. Rend. Acad. Sci. U.R.S.S.*, **24**, 287–89 (1939).—A new mineral of the sepiolite type (α-sepiolite) is a magnesian analogue of a montmorillonite mineral; it has the formula $3MgO\cdot\cdot 3.66SiO_2\cdot 5.5H_2O$. Setting up a series of analogues of the montmorillonite and sepiolite types with gradually increasing SiO_2 contents, E. concludes that through the beidellites, the hydrosiallites of the montmorillonite type are connected with the kaolinite-halloysite type. The ϵ-montmorillonite, having the highest silica content, probably has an analogue, ϵ-sepiolite, that is as yet unknown to exist. P.B. & E.S.

Constitution and classification of the clay minerals. J. S. HOSKING. *Australian Chem. Inst. Jour. & Proc.*, **7**, 234–50 (1940); *Chem. Abs.*, **34**, 7790 (1940).—H. reviews recent work on the composition and structures of the minerals present in clays and in the colloidal fractions of soils. The classification of the minerals in the light of this knowledge is discussed. 54 references.

Effect of alumina on the optical properties of tremolite. D. P. GRIGOR'EV. *Compt. Rend. Acad. Sci. U.R.S.S.*, **23**, 71–73 (1939).—With additions of alumina the refractive indices decrease; the birefringence and the angle of extinction also decrease slightly. P.B. & E.S.

Electroosmose treatment of a kaolin from White River. V. L. BOSAZZA. *Bull. Minerals Research Lab., Univ. Witwatersrand*, No. 3, pp. 10–13 (1939).—A kaolin sample from White River, Transvaal, was treated by electroosmosis to improve the quality. Chemical analysis showed a ferric oxide content of nearly 4%, and the grading indicated some of this to be in the form of hematite. The greater part of the iron oxide, however, exists in some form which is not easily discernible. Much of it is probably in solid solution in the kaolinite molecule, replacing alumina. Details of the electroosmose treatment are given, and the process is shown to be merely a dewatering action. The treated clay was in no way superior to the raw material. ABSTRACTER'S NOTE: Since this paper was published more detailed work on the White River clay and other clays has been done. A considerable amount of electrochemical precipitation on aluminum and type-metal electrodes has shown that a detailed size analysis is a valuable means of explaining the process, e.g., clays of similar chemical composition behaved differently in the cell. Fractionation and microscopic examination showed the kaolinite to exist mainly in the crystalline form in those clays which were not precipitated by the electric current; these clays were difficult to disperse. Coarsely crystalline kaolinite is very common in South African kaolins. The White River kaolin is one of the few which contain a high proportion of colloidal material. V.L.B.

Fundamental study of clay: I, Preparation of a purified kaolinite suspension. A. L. JOHNSON AND F. H. NORTON. *Jour. Amer. Ceram. Soc.*, **24** [2] 64–69 (1941).—7 figures, 12 references.

Genesis of montmorillonite and kaolinite and conditions of their joint occurrence in the colloids of soils and clays. I. D. SEDLETSKII. *Compt. Rend. Acad. Sci. U.R.S.S.*, **22**, 510–14 (1939); see "Theoretical . . .," *Ceram. Abs.*, **19** [6] 148 (1940). P.B. & E.S.

Heavy-mineral zones of Louisiana and Texas Gulf Coast sediments. WILLIAM M. COGEN. *Bull. Amer. Assn. Petroleum Geologists*, **24** [12] 2069–2101 (1940).—Heavy-mineral assemblages of five Cenozoic zones in Texas and Louisiana are described and illustrated. G.M.H.

Isomorphous replacement and superlattice structures in the plagioclase feldspars. S. H. CHAO AND W. H. TAYLOR. *Proc. Roy. Soc.* [London], **A176**, 76–87 (1940).—From X-ray oscillation and rotation photographs of a limited number of plagioclase feldspars, it seems probable that the structure type depends upon the chemical composition in the following way. From pure soda feldspar to at least 22% lime feldspar, there exists an isomorphous series with the albite structure. Near pure lime feldspar there is probably a similar range of isomorphism with the anorthite structure. Intermediate structures are explained in terms of alternating sheets of albite and anorthite, but more experimental data are needed. A.P.

Italian bauxites. CAMILLO CREMA. *Mat. prime Italia & Imp.*, **9**, 424–30 (1939); *Rev. Géol.*, **20**, 149–50; *Chem. Abs.*, **34**, 8187 (1940).—Italian bauxites contain Al_2O_3 50 to 60, SiO_2 2 to 6, and iron oxide 15 to 25%.

Kaolin and bauxite (in Victoria). W. BARAGWANATH. *Mining Geol. Jour.* [Australia], **2**, 115–17 (1940); *Chem. Abs.*, **34**, 6901 (1940).—Three classes of kaolin deposits occur in Victoria, viz., (1) large masses of altered granite, as at Bulla, Dandenong, Lal lal, Plttong, and Pgalong; (2) decomposed feldspathic dikes, as at Egerton, Ballarat, Stawell, and Gisborne; and (3) transported clays, as at Bacchus Marsh, Rownley, and elsewhere. Class 1 includes the largest deposits.

Petrography of clays: I. V. N. RAZUMOVA. *Trudy Vsesoyuz. Nauch.-Issledovatel. Inst. Mineral. Syr'ya*, No. 137, pp. 3–56 (in English, 48–49) (1939); *Chimie & Industrie*, **43** [6] 472 (1940); *Chem. Abs.*, **34**, 7219 (1940).—Clays can be characterized by means of four dyes, crystal violet, rhodamine, patent blue, and methyl green, in aqueous or alcoholic solution; the optical properties, etc., of the substance are taken into consideration at the same time. The dichroism of the colored clay particles is governed by the oriented arrangement of the dye micelles at the surface of the crystal. The ease of coloring of argillaceous minerals is governed by their surface properties.

Reactions for the identification of talc and kaolin. V. LUCAS. *Rev. Assoc. Brasil. Farm.*, **20**, 424 (1939); *Anales Farm. Bioquím.* [Buenos Aires], Supl. **11**, 34 (1940); *Chem. Abs.*, **34**, 7214 (1940).—Mix 1 gm. of the powder with 1 cc. concentrated H_2SO_4, heat until white fumes appear, cool, dilute with 10 cc. water, and filter. To the filtrate slowly add 15% NaOH solution. A gelatinous precipitate soluble in excess of NaOH [$Al(OH)_3$] indicates kaolin, and a precipitate insoluble in excess of NaOH [$Mg(OH)_2$] indicates talc.

Relative resistance to abrasion of mineral grains of sand size. GEORGE A. THIEL. *Jour. Sed. Petrology*, **10** [3] 103–24 (1940).—Photomicrographs show the relative resistance to abrasion in running water of mineral grains of sand size. G.M.H.

SEPARATE PUBLICATIONS

Geology and Mineral Resources of Washington County, Oklahoma. MALCOLM C. OAKES. *Oklahoma Geol. Sur-*

vey Bull., No. 62 (1940). 208 pp., 18 tables, 19 figs., 3 maps. Reviewed in *Bull. Amer. Assn. Petroleum Geologists*, **24** [12] 2185–86 (1940). G.M.H.

Recent Marine Sediments, A Symposium. Published by American Assn. of Petroleum Geologists, 1939. **Properties of clay.** RALPH E. GRIM. Pp. 466–95; *Chem. Abs.*, **34**, 2541 (1940).—G. gives an extensive review of the clay minerals, including optical, chemical, and dehydration properties, base-exchange capacities, lattice structures, distribution, origin, composition, and the relation of physical properties to mineral composition. 161 references.

PATENTS

Dolomitic magnesium carbonate composition. DOROTHY H. GRUNWALD (Plant Rubber and Asbestos Works). Can. 392,801, Nov. 26, 1940 (Aug. 30, 1938). G.M.H.

Mineral concentration. CHARLES H. PEDDRICK, JR., AND JOSEPH H. WEIS (Feldspathic Research Corp.). Can. 392,899, Dec. 3, 1940 (Aug. 8, 1938).—A method of reducing the free-silica content of minerals comprises fine-grinding, treating the particles with a reagent containing a fluorine radical, simultaneously heating for a sufficient time to render the particles selectively susceptible to an electrostatic field, drying the treated particles, and then subjecting them to an electrostatic field to cause the free-silica particles to selectively segregate from the remaining constituents. G.M.H.

Production of granular calcined brucite. M. F. GOUDGE. Brit. 529,614, Dec. 4, 1940 (June 5, 1939).

Chemistry and Physics

Activating SiO_2 by pretreatment with O_2. J. ARVID HEDVALL AND O. RUNEHAGEN. *Naturwissenschaften*, **28** [27] 429–30 (1940).—By pretreating SiO_2 at 900°C. for 2 hr. with O_2 and then "washing" it with air or N_2 at the same temperature, the reaction between 2CaO and SiO_2 can be increased by 20 to 45% at 900° to 1000°C. The increase takes place with all structure types of SiO_2. A pretreatment temperature of 600°C. is almost as effective. SO_2 and SO_3 also affect surface conditions favorably. J.M.N.

Alkali determinations by the J. Lawrence Smith method—modifications. L. C. ATHY AND R. K. TAYLOR. *Chemist-Analyst*, **29** [4] 76–77, 80 (1940).—Suggested modifications include (1) grinding the sample wet with ethanol, (2) adding $CaCl_2$ and Fe_2O_3 to the sample, (3) igniting some $CaCO_3$ in the crucible, slaking, and coating the walls with the lime, (4) use of 8-hydroxyquinoline to remove traces of Mg, and (5) adding ethanol before the final complete drying of the alkali chlorides. A.P.

Chemical equilibrium and the control of furnace atmospheres—review of equilibrium data. J. B. AUSTIN AND M. J. DAY. *Ind. Eng. Chem.*, **33** [1] 23–31 (1941).—The concept of equilibrium and the properties of the equilibrium constant, particularly its significance in relation to the control of conditioned atmospheres in metallurgical furnaces, are described and illustrated by typical reactions for iron and steel. The equilibrium constants for the following reactions are critically reviewed, and selected values are given: $Fe + H_2O = FeO + H_2$; $Fe + CO_2 = FeO + CO$; $CO + H_2O = CO_2 + H_2$; $C + CO_2 = 2CO$; $CH_4 = C + 2H_2$; $Fe_3C + CO_2 = 3Fe + 2CO$; $CH_4 + 3Fe = Fe_3C + 2H_2$. Illustrated. F.G.H.

Colorimetric analysis of a two-component color system. HAROLD W. KNUDSON, VILLIERS W. MELOCHE, AND CHANCEY JUDAY. *Ind. Eng. Chem., Anal. Ed.*, **12** [12] 715–18 (1940).—One method of resolution of a two-component color system using a photoelectric filter photometer depends on the ability to isolate part of the absorption band of the desired component by means of a suitable filter. The other method depends on the differential separation of the absorption bands by means of two appropriately selected filters. The details for calculating the concentration of one desired component in unknown mixtures with the second component are given. Illustrated. F.G.H.

Crystallographic investigation of artificial mullite. D. P. GRIGOR'EV AND I. I. SHAFRANOVSKIĬ. *Compt. Rend. Acad. Sci. U.R.S.S.*, **23**, 933–34 (1939).—Mullite crystals were subjected to goniometric and optical crystal analyses; the respective data are given. P.B. & E.S.

Determination of organic sulfur in combustible gas. F. M. ROGERS AND R. F. BALDASTE. *Ind. Eng. Chem., Anal. Ed.*, **12** [12] 724–25 (1940).—Purified air is used to burn the gas in a special burner. The sulfur dioxide resulting from the combustion of the gas is absorbed in sodium hypobromite solution, and the sulfate in this solution is determined turbidimetrically. The method is adapted to the determination of less than 0.2 grain (12.96 mg.) of sulfur per 100 cu. ft. (283.2×10^4 cc.) of gas. Illustrated. F.G.H.

Effect of the addition of salts on the crystal growth of alumina. TOKITI NODA AND YOSIHIRO ISIHARA. *Jour. Soc. Chem. Ind. Japan*, **43** [3] 166–68 (1940); Supp. Binding, pp. 71–72B.—The effect of the addition of salts on the crystal growth of alumina has been worked out as in the case of infusible oxides such as magnesia and lime (*ibid.*, **41** [3] 74B (1938); **42** [8] 265B (1939)). The salts used were alkali fluorides and chlorides, alkali-earth fluorides and chlorides, aluminum fluoride, ammonium fluoride, and ammonium chloride. All of these salts accelerate the crystal growth of alumina. In general, their effectiveness follows their periodical order. Among compounds of the same group, the metallic element having the smallest atomic number is most effective. Fluorides (with some exceptions) usually have a greater effect than chlorides. Different kinds of alumina crystals may be produced with addition agents. M.T.

Effect of the addition of salt vapor on the synthesis and crystal growth of spinel. TOKITI NODA AND MASATOSI HASEGAWA. *Jour. Soc. Chem. Ind. Japan*, **43** [3] 169–72 (1940); Supp. Binding, pp. 72–73B.—While magnesia spinel was being formed by reaction in the solid state from magnesia and alumina and while the crystal of the spinel thus prepared was growing, salt vapor was added in each case to determine its influence on crystal growth. Results showed that there is a general rule for the effect of the addition of salts on crystal growth which is the same as that for the crystallization of lime, magnesia, and alumina aggregates. The salts were effective in the following order: $LiX > NaX > KX$; $MgX_2 > CaX_2 > SrX_2 > BaX_2$; and $AF > ACl$, $BF_2 > BCl_2$, where A = alkali metal, B = alkali-earth metal, and X = fluoride or chloride. The influence of the addition of salt vapor on the efficiency of spinel formation appeared to be complex. The percentage of spinel formed was usually increased by the addition (from 74% to more than 90%). The addition of fluorides, however, especially alkali fluorides, which were markedly effective in accelerating crystal growth, resulted in an increase in the acid-soluble portion of the sample over that when no addition was made. This is explained by the formation of acid-soluble layers containing fluorine around the spinel crystals. Sintered spinel was also obtained by heating the sample in tablet form in a Tammann furnace at 1600° to 1700°C. M.T.

Effect of various catalysts on conversion of quartz to cristobalite and tridymite at high temperatures. NELSON W. TAYLOR AND CHO-YUAN LIN. *Jour. Amer. Ceram. Soc.*, **24** [2] 57–63 (1941).—14 tables, 4 references.

Ferrocyanidometric method for determining iron oxide. V. D. FEDOSEEV AND V. I. VOLKOVA. *Prom. Stroitel. Materialov*, **2** [6] 89–90 (1940).—The method of Bodin (*Zavodskaya Lab.*, **8**, 32–33 (1939)) has been adapted, with some modifications, to the determination of iron in Portland cement. A 0.5-gm. sample is mixed with 1 gm. NH_4Cl in a porcelain cup and treated with 10 ml. of HCl

(specific gravity 1.19); 5 to 6 ml. HNO_3 (specific gravity 1.4) are added to oxidize ferrous iron to ferric iron. After evaporation to dryness on a water or sand bath and cooling, 10 ml. HCl are added; the solution is heated to boiling and put in a 250-ml. flask having a ground stopper. The determination is continued according to Bodin's method. A modified method of determining Mg volumetrically has also been worked out; the sample is prepared according to the Killig method, and the Mg is determined according to the Hough and Fickle method. P.B. & E.S.

Improved persulfate-arsenite method for the determination of manganese. A. S. MUELLER. *Chemist-Analyst*, **29** [4] 78–79 (1940).—Manganese is separated from nickel, cobalt, copper, and zinc by precipitation with ammonium hydroxide and ammonium persulfate. The hydrated manganese manganite obtained is converted to the sulfate by solution in sulfurous acid and by boiling off the excess sulfur dioxide before the usual titration with sodium arsenite. A.P.

Melting and crystal structure. J. W. H. OLDHAM AND A. R. UBBELOHDE. *Proc. Roy. Soc.* [London], **A176**, 50–75 (1940).—The role of various types of lattice flaws is discussed in regard to their bearing on melting and crystal structure. A picture of melting is suggested in which a network of cooperative flaws breaks the crystal into a mosaic or aggregate of crystalline micelles and in which the solid-liquid transition is comparable to a gel-sol transition. A.P.

Morin reaction for beryllium. E. B. SANDELL. *Ind. Eng. Chem., Anal. Ed.*, **12** [12] 762–64 (1940).—The morin-beryllium fluorescence reaction first described by Zermatten has been further investigated. Zinc also gives a fluorescence with morin in daylight in a strongly basic solution, but cyanide destroys this fluorescence without affecting the beryllium fluorescence. In ultraviolet light, calcium and lithium show a fluorescence with the reagent under the conditions of the beryllium test; the interference of small amounts of calcium can be prevented by the addition of sodium pyrophosphate. See *Ceram. Abs.*, **20** [2] 57 (1941). F.G.H.

Optical analysis of strontium aluminates. N. A. TOROPOV. *Compt. Rend. Acad. Sci. U. R. S. S.*, **23**, 74–75 (1939).—Strontium aluminates were synthesized and examined microscopically. The characteristics of the different crystalline phases of the system are given. P.B. & E.S.

Quantitative spectrographic analysis: II, Method of relative intensity relations with normalized external standard. J. T. MIRELES MALPICA. *Gen. Elec. Rev.*, **43** [8] 333–35 (1940).—To find the order of error due to variations in spectral response from plate to plate, a number of plates were checked with a continuous spectrum from a concentrated tungsten filament. Where the internal-standard method fails, the external-standard method gives satisfactory results. For Part I see *Ceram. Abs.*, **19** [10] 244 (1940). L.E.T.

Rational analysis of clays and silicates. RENÉ DARRIGOS. *Chim. Chronika* [Greece], **10–12**, 233–35 (1938); *Chem. Abs.*, **34**, 7556 (1940).—Allophanoid clays are treated with hot H_2SO_4, and the SiO_2 thus separated is dissolved in 47% caustic alkali. The solution is evaporated to dryness and heated to redness, and the SiO_2 which is dissociated from the kaolin is determined from the weight of the Al_2O_3 precipitated by NH_4OH or 8-hydroxyquinoline.

Slag system. R. HAY AND JAMES WHITE. *Jour. West Scot. Iron & Steel Inst.*, **47** [6] 87 (1939–40).—The equilibrium diagrams of the following systems are discussed: (1) $CaO–Fe_2O_3$, (2) CaO–FeO, (3) CaO–Fe–Fe_2O_3, and (4) CaO–FeO–Fe_2O_3–SiO_2. CaO retards the dissociation of Fe_2O_3 at elevated temperatures. In the system CaO–FeO, the melts containing 30% or less of CaO did not slake. B.C.R.

System alkali oxides–CaO–Al_2O_3–SiO_2–CO_2: X, Equilibria in the quaternary system $Na_2O–CaO–SiO_2–CO_2$. C. KRÖGER AND K. W. ILLNER. *Z. Anorg. & Allgem. Chem.*, **243** [2] 209–30 (1940).—The authors studied the dissociation of $Na_2Ca(CO_3)_2$. The double carbonate melted at 813°. Up to the melting point, the dissociation followed the reaction $[Na_2Ca(CO_3)_2] \rightarrow [Na_2CO_3] + [CaO] + CO_2$. Because of mixed crystal formation, the equilibrium is bivariant at first. The action of SiO_2 on the double carbonate was also investigated. The reaction follows: $3[Na_2Ca(CO_3)_2] + 6[SiO_2] = [2Na_2O \cdot CaO \cdot 3SiO_2] + [Na_2O \cdot 2CaO \cdot 3SiO_2] + 6(CO_2)$. The formation of $[Na_2O \cdot 2CaO \cdot 3SiO_2]$ was verified by X-ray diagrams. The reaction behavior of the ternary compound $Na_2O \cdot 3CaO \cdot 6SiO_2$ was investigated. $Na_2O \cdot 3CaO \cdot 6SiO_2$ reacts with $Na_2Ca(CO_3)_2$ to form the equilibrium $[Na_2Ca(CO_3)_2] + [Na_2O \cdot 3CaO \cdot 6SiO_2] \rightleftharpoons 2[Na_2O \cdot 2CaO \cdot 3SiO_2] + 2(CO_2)$. X-ray diagrams also verified the reaction $7Na_2Ca(CO_3)_2 + 12Na_2Si_2O_5 + Na_2O \cdot 3CaO \cdot 6SiO_2$. The authors investigated the reaction pressures of ternary metasilicates. The *p-t* diagram of $Na_2O–CaO–SiO_2–CO_2$ shows a sextuple point with the following phases present: SiO_2, $Na_2Ca(CO_3)_2$, $Na_2O \cdot 3CaO \cdot 6SiO_2$, $Na_2O \cdot 2CaO \cdot 3SiO_2$, $2Na_2O \cdot CaO \cdot 3SiO_2$, and CO_2. The ternary metasilicates follow the bivariant equilibrium: $Na_2O \cdot 2CaO \cdot 3SiO_2 + 2Na_2O \cdot CaO \cdot 3SiO_2 + 3Na_2Ca(CO_3)_2 \rightarrow 6(Na_2O \cdot CaO \cdot SiO_2) + 6CO_2$. For Part VIII see *Ceram. Abs.*, **19** [11] 270 (1940); for Part IX see "Reaction. . .," *ibid.*, p. 269. R.K.

PATENTS

Preparation of pure titanium dioxide. W. W. PLECHNER AND A. W. HIXSON (National Lead Co.). U. S. 21,693, Jan. 14, 1941 (Dec. 15, 1939); reissue of original 2,113,946, April 12, 1938 (Nov. 6, 1936).—A process for the preparation of titanium dioxide having rutile crystalline structure comprises hydrolytically precipitating nonpeptized, easily filterable, hydrous titanium oxide from an aqueous titanium chloride solution containing a small amount of a negative, polyvalent coagulant ion, separating the hydrous titanium oxide, and calcining it to rutile crystalline structure.

Producing compounds of barium and strontium. L. O. HILL AND SAMPSON ISENBERG (L. O. Hill and McLaughlin & Wallenstein). U. S. 2,225,633, Dec. 24, 1940 (Feb. 17, 1938).—The method of producing barium hydroxide comprises providing a fused mass of sodium hydroxide containing barytes dissolved therein, allowing the resulting mass to cool, pulverizing it, dissolving out barium hydroxide with a solvent at least a substantial part of which comprises ethylene glycol, and treating the resulting solution with water to precipitate out barium hydrate.

General

Advanced silicosis. ANON. *Ohio Industrial Commission Monitor*, **13**, 121 (Aug., 1940).—A foreman employed in the clay room of a plant filed application for compensation for permanent and total disability as a result of silicosis in an advanced stage. He had worked in the clay room for twenty years and was constantly exposed to dust which contained 30% free silica. A dust count made at the plant several years ago indicated the dangerous condition, and the employer took steps for dust elimination; installation of modern equipment brought about reasonably safe conditions. This lightened the exposure to which the claimant was subjected in the past two years, but it was held that the claim satisfied all the statutory requirements regarding silicosis. The Commission found the claimant permanently and totally disabled as the result of advanced silicosis and ordered compensation paid accordingly. F.S.M.

Caulking whiteware conduits. ANON. *Beizerei* (in *Emailwaren-Ind.*, **17** [39–40]), **5** [10] 19 (1940).—When an elastic cement is applied to protect socket joints in whiteware pipe used for carrying off waste acid or alkali water, the pipe cannot be separated later for repairing. To overcome this difficulty, an asphalt cement has been developed

which seals well, is resistant to chemical agents, and is sufficiently elastic. It is poured while warm into the socket (which has previously been given a streaking of tar) through a cork ring laid around the edge. When the asphalt is cold, the ring is removed. If necessary, the socket may be removed for repairs by heating the cemented places carefully. M.V.C.

Complete boiler control maintains balanced operation at Des Moines. J. F. McLAUGHLIN. *Combustion*, **11** [8] 22–25 (1940).—In a high-pressure, high-temperature boiler installation supplying steam to a 35,000-kw. turbine, combustion control is supplemented by automatic control of the feedwater, pressure reducing and desuperheating, steam temperature, and the temperature of the mixture of cold and preheated air supplied to the pulverizers. H.E.S.

Correlation of steam and electric power in industrial plants. G. G. HOLLINS. *Combustion*, **11** [10] 29–31 (1940).—H. discusses the factors that enter into a study of the most desirable heat balance (as dictated by prevailing steam and power demands) conducive to minimum operating costs in an industrial power plant. Steam conditions, generated and purchased power, types and combinations of equipment, and steam vs. electric drive for auxiliaries are considered. H.E.S.

Death of employee from pneumonia held compensable. ANON. *U. S. Dept. Labor, Monthly Labor Rev.*, **51**, 954 (Oct., 1940).—The Court of Appeals of Ohio held that the death of an employee from pneumonia was compensable under the Workmen's Compensation Law (Johnson vs. Industrial Commission, 27 N.E. (2d) 418). The employee had been compelled to go from a tank where the temperature registered 110° to 120° to the outside where the temperature ranged from 69° to 88°. It was, the court said, an unusual, sudden, and unexpected happening at a particular time which resulted in physical injury accidental in origin and cause. Compensation was therefore awarded. F.S.M.

Diatomaceous earth as cause of silicosis. W. MEYER. *Farben-Ztg.*, **45**, 309–10 (May 18, 1940).—M. discusses the problem of diatomaceous earth as a possible cause of silicosis. He considers the characteristic physical properties and uses of this substance and reviews investigations on silicosis alleged to be caused by it. F.S.M.

Dust control: I, Exhaust devices for hand pneumatic tools. W. C. L. HEMEON. *Heating & Ventilating*, **37**, 41–45 (June, 1940). **II, Exhaust for surfacing machines and abrasive blasting.** *Ibid.*, pp. 54–58 (July, 1940).—The possibilities of improved control of dust with economical volumes of air by modification of the conventional hood design to provide a partial enclosure of the cutting tool are discussed. Variations of this idea are shown in diagrams and photographs. Baffle disks for the deflection of leakage air from the pneumatic head are of value in reducing the dispersion of dust from the working surface. An air flow of 600 cu. ft. per min. is sufficient to control dust when the encircling hood and baffle disk are employed. Even lower velocities may be used, but they are not satisfactory for the removal of small chips. For the ventilation of blasting rooms, only small volumes of air are needed to prevent outward escape of dust, 150 cu. ft. per min. per foot of length being considered adequate. The exhaust outlet should be arranged to withdraw as little as possible of the abrasive, since the material is both expensive and reusable. Shape carving may be done inside a ventilated room by a workman wearing an air helmet, or a curtain with armholes and a glass top may be lowered over the work. Very small volumes of air are sufficient to provide satisfactory visibility for this operation (probably 100 to 200 cu. ft. per min. if the enclosure is reasonably tight). F.S.M.

Employee entitled to damages for occupational disease. ANON. *U. S. Dept. Labor, Monthly Labor Rev.*, **51**, 953–54 (Oct., 1940).—According to a decision of the Federal District Court in Colorado (Cason vs. American Brake Shoe & Foundry Co., 32 Fed. Sup. 680), an employee has a right of action against his employer for an occupational disease contracted in the course of the employment and caused by the negligence of the employer, even though both employer and employee had accepted the provisions of the State workmen's compensation act. The court declared that exemption of the employer from liability would tend to foster negligence of a kind likely to produce disease and render all regulation of working conditions, factories, etc., mere gestures. F.S.M.

Fewer silicosis claims in Wisconsin. ANON. *U. S. Dept. Labor, Labor Standards*, **3**, 68 (July-Aug., 1940).—According to the Wisconsin Industrial Commission's report for 1939, the great influx of claims based on silicosis, which reached its height in 1933 and 1934, has been reduced to a point where no special handling is required. At one time several hundred cases awaited determination. At the present time, all cases have been decided with the exception of the small current flow which amounts to about five cases per month. Wisconsin industries have discharged their current obligation to silicotics, and the future burden of cases will not be excessive nor will it need an essentially different treatment from that given to accident cases. F.S.M.

Industrial aspects of ear, nose, and throat practice. H. A. FLETCHER. *Jour. Amer. Med. Assn.*, **115**, 496–501 (Aug. 17, 1940).—The industrial phases in the work of the otolaryngologist are presented. F. lays down broad principles, based upon his own experience, for the physician new to these aspects. Pertinent examples illustrating practical applications are given. An interesting discussion of compensation for loss of hearing is included. F.S.M.

Lung function in silicotics: I, Capacity of the lungs and conditions of the alveolar ventilation. E. ROELSEN AND N. BAY. *Acta Med. Scand.*, **103**, 55–82 (1940); abstracted in *Bull. Hyg.*, **15**, 346 (June, 1940).—The vital capacity of twenty-nine silicotics was decreased, and the residual air often increased. The ratio residual air × 100/ total capacity is generally heightened in stages II and III of silicosis, but there is no sure difference between the two groups. The average magnitude of this ratio is 29, 38, and 41, respectively, for silicosis of stages I, II, and III. The increase of this ratio is due partly to reduced elasticity of the lungs with increased residual air and partly to a reduction of the total capacity. The distribution in the alveolar air of the inspiration air was examined in eighteen patients with silicosis by fractional sampling of the alveolar air after a single inspiration of pure hydrogen. Alveolar ventilation was very unequal, conforming with that previously found in patients with emphysema. The maximal percentage difference of ventilation of different sections of the lung was found to be 47% (average) per liter alveolar air expired, corresponding to stages II and III of silicosis, but there is no great difference between the two groups. The increase of the detected percentage difference of ventilation is explained by reduced elasticity of the lungs, analogous to the conditions found in emphysema. F.S.M.

New York holds hearing on silicosis codes. ANON. *U. S. Dept. Labor, Labor Standards*, **3**, 68 (July-Aug., 1940).—Public hearings on three proposed industrial codes for the control of silicosis and allied occupational disease hazards were held recently by the New York Board of Standards and Appeals in five cities throughout the State. The codes are (1) Control of Silica Dust in the Stone-Cutting and Stone-Finishing Industry, (2) Control of Silica Dust in the Stone-Crushing Industry, and (3) Revision of *Industrial Code Bull.*, No. 10, relating to the Equipment, Maintenance, and Sanitation of Foundries and the Control of Dusts, Gases, and Fumes in Foundries. William J. Picard, Chairman of the Board of Standards and Appeals, states that adoption of these codes, which have the full force and effect of law, together with the Rock-Drilling Code issued in 1937, will cover the principal exposures to silica hazards in New York. F.S.M.

THE AMERICAN CERAMIC SOCIETY TRUSTEES AND OFFICERS FOR 1941–1942

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